

HOW TO DRAIN A HOUSE



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How to Drain a House

Practical Information

for Householders

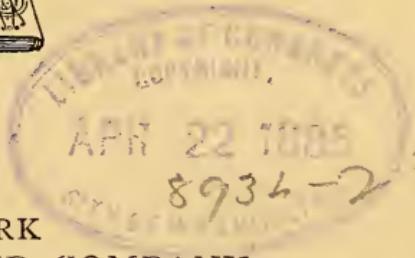
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BY

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(Newport, R. I.)

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PREFATORY: OUR ENEMY THE DRAINS.

The drains in average modern houses are probably the most serious and prevalent enemies with which struggling humanity has to contend. But, at the worst, they are only incidentally enemies, and they are *never* necessarily so.

All of the intended purposes of the drains are wholly beneficial. With all of their defects, it is not too much to say that on the whole the world is much better off with them than it would have been without them. Defective though they often are, whether in the house or in the

street, they have probably been, next after the introduction of a pure water-supply, the most important factor in the reduction of the death-rate.

That a country town, depending entirely on outside privies and on cess-pools, with all that their use implies in the way of exposure and irregularity of habits, and of the fouling of the ground and the air—would be vastly improved in its sanitary condition by the introduction of even an imperfect system of sewerage and with plumbing-work of a very low and ordinary character, is not to be doubted. Therefore, at the worst, one enemy has displaced another, and the new one is much less to be dreaded than the old.

What we still need is continued progress in the right direction. As indoor water-closets are better than out-of-door privies; as defective waste-pipes are better

than none ; and as bad sewers are better than cess-pools, so will good substitutes for all of these defective things lead to still further improvement.

In the following pages the subject is approached entirely from the point of view of the individual householder—he who has got so far on in wisdom as to know that imperfect drainage is an enemy to the well-being of his household, and that by abolishing the imperfections, the enemy can be disarmed and made a most useful ally.

The drainage system is, however, a trustworthy ally *only so long as the woman of the house holds it under close and careful supervision.*

Her whole duty is not done when her husband has paid a good round sum to the engineer and to the plumber. It is only begun.

There has been placed under her con-

trol a means of safety, or an engine of destruction, according as she performs her duty, or neglects it. She can not safely delegate her responsibility to her servants. Her own eye must see that at no point, her neglect, at any time, permitted even the beginning of filth—for the beginning of filth is the beginning of danger. It marks the desertion of the ally to the ranks of the enemy.

G. E. W., Jr.

NEWPORT, R. I., December, 1884.

CONTENTS.

CHAPTER.	PAGE.
PREFATORY : OUR ENEMY THE DRAINS, .	3
I. HOUSE-DRAINS AND HEALTH,	1
II. DRAINS OF THE AVERAGE HOUSE,	12
III. THE POLICY ADOPTED,	22
IV. THE HEALTHFULNESS OF THE HOUSE,	24
V. FOUNDATION AND CELLAR,	29
VI. FOUL DRAINAGE,	51
VII. SPECIFIC ADVICE—AS TO PLUMBING,	55
VIII. THE SEWER-GAS QUESTION,	62
IX. HOW THE SIMPLIFICATION OF PLUMBING WILL AFFECT THE PLUMBER,	67
X. MAIN LINE AND MAIN TRAPS,	72
XI. FRESH-AIR INLETS,	78
XII. MATERIAL AND CONSTRUCTION OF THE MAIN DRAIN,	81
XIII. THE SOIL-PIPE,	85
XIV. VENTILATING COWLS ON SOIL-PIPES,	92
XV. TRAPS AND TRAP VENTILATION,	96
XVI. PUTNAM'S TRAP,	115

XVII.	PLUMBING APPLIANCES,	120
XVIII.	SIMPLICITY, ECONOMY, AND CONVENIENCE, .	124
XIX.	WASH-STANDS,	127
XX.	WATER-CLOSETS—THE DECECO,	131
XXI.	SINKS—THE DECECO FLUSH-POT,	143
XXII.	OVERFLOWS AND STOP-COCKS,	150
XXIII.	AN EXAMPLE OF SIMPLE AND GOOD WORK, .	160
XXIV.	OWNERS, ARCHITECTS AND PLUMBERS, . .	164
XXV.	SEWAGE DISPOSAL FOR ISOLATED HOUSES, .	172
XXVI.	SUB-SURFACE IRRIGATION,	194

ILLUSTRATIONS.

FIGURE.	PAGE.
1. GRAVEL DRAIN UNDER CELLAR FLOOR NEAR FOUNDATION,	33
2. TILE DRAIN, WITH MUSLIN JOINT,	34
3. THE TOP FINISH OF A SOIL-PIPE,	93
4. THE CROOKS AND ANGLES OF TRAP-VENT PIPES,	105
5. PUTNAM'S TRAP,	117
6. THE DECECO WATER-CLOSET,	135
7. " " FLUSH-POT FOR SINKS,	146
8. HIDDEN OVERFLOW OF BATH,	152
9. STANDING OVERFLOW AND PLUG FOR BATH,	155
10. FIELD'S FLUSH-TANK,	191
11. SETTLING BASIN AND FLUSH-TANK, (PLAN)	196
12. " " " " (SECTION)	197
13. DETAILS OF ROGERS FIELD'S SIPHON,	198
14. BRANCH PIECE FOR CONNECTING THE TILES,	206
15. TILE,	209
16. GUTTER,	209
17. CAP,	209
18. GUTTER, TILE, AND CAP AS LAID, (SECTION)	209
19. METHOD OF LAYING ABSORPTION DRAINS,	211
20. ARRANGEMENT OF FLUSH TANK AND DRAINS FOR A SMALL LOT,	218

HOW TO DRAIN A HOUSE.

CHAPTER I.

HOUSE DRAINS AND HEALTH.

FORTY years ago the best houses in American cities were little if at all better in the matter of drainage than are the best houses of Paris, with very rare exceptions, to-day. They had at best only one drain to remove the kitchen waste and another to drain the cellar. All the water used was carried by hand and it was used in limited quantities. The bath was an exceptional luxury ; the water-closet was almost unknown, and the unspeakable horrors of the privy, the close-

stool and the sick-chair—still dominant in undrained houses, and especially in country houses—were accepted as an inevitable incident of human life. Happily, we are now emerging from this barbaric condition, and are learning to regulate our appliances according to the dictates of health and decency. A dozen years ago in a pamphlet description of the earth-closet, then recently invented, I wrote the following, which is as true of country houses now as it was then :

Out-of-door privies, those temples of fame and graves of decency, that disfigure almost every country home in America, and raise their suggestive heads above the garden-walls of elegant town-houses, are, I believe, doomed to disappear from off the face of the earth. Twenty years ago, every back-yard in New York City was provided with one of these buildings ; now, since the water-closet has come into universal

use, probably there are not twenty of them to the square mile. Twenty years hence, it is to be hoped, they will become equally rare in smaller towns and in the country. That they are objectionable on the score of decency and comfort, will be confessed by all. What is not so generally understood is their pernicious effect upon health. The influence of subterranean stores of fecal matter in the propagation of disease has already been referred to, and will be more fully discussed hereafter; but that which produces, in the aggregate, far worse results—the aggravation of the difficulties of delicate females—has attracted less attention than its importance deserves. It is universally admitted that nothing is more injurious to health than irregularity and the undue retention of the rejectamenta of the intestines. It is not necessary to quote scientific authority to prove to any

person of intelligence that in prompt and regular attention to this duty lies the cardinal secret of health. We have all been reminded, in our own persons, that our health and efficiency, as well as our cheerfulness and good humor, depend on perfect regularity in this regard. There can be little question that the prevailing female complaints are often induced, and always intensified, by disorders of the digestive organs, and the oppression in the lower regions that neglect in this matter causes. Admitting the justness of the view, let us see what chance a woman living in the country has to escape the direst evils that "delicate health" has in store for its victims. The privy stands, perhaps, at the bottom of the garden, fifty yards from the house, approached by a walk bordered by long grass, which is always wet except during the sunny part of the day, overhung by shrubbery and vines,

which are often dripping with wet, and sometimes exposed to the public gaze. In winter, snow-drifts block the way, and during rain there is no shelter from any side. The house itself is fearfully cold, if not drifted half-full with snow or flooded with rain. A woman who is comfortably housed during stormy weather will, if it is possible, postpone for days together the dreadful necessity for exposure that such conditions imply. If the walk is exposed to a neighboring work-shop window, the visit will probably be put off until dusk. In either case, no amount of reasoning will convince a woman that it is her duty, for the sake of preventing troubles of which she is yet ignorant, to expose herself to the danger, the discomfort, and the annoyance that regularity under such circumstances implies. I pass over now the barbarous foulness and the stifling odor of the privy-

vault. It is only as an unavoidable evil that these have been tolerated; but I can not too strongly urge attention to the point taken above, and insist on the fact that every consideration of humanity, and of the welfare not only of our own families, but of the whole community, demands a speedy reform of this abuse. It will hardly be believed by my more civilized readers that, over more than half of the older settled parts of the United States, even the every-way objectionable system that I have described is comparatively unknown, and that the corn-field and the thicket are the only retreat provided, while the majority of farmers' houses, even at the North, are most inadequately supplied. In view of the foregoing facts, I make no apology for calling the attention of women themselves to this important matter, believing that they will universally con-

cede that, however much of elegance and comfort may surround them in the appointments of their homes, their mode of life is neither decent, civilized, nor safe, unless they are provided with the conveniences that the water-closet and the earth-closet alone make possible.

As a positive source of disease, and as the occasion of a most injurious irregularity, the barbarous appliances of our ancestors, still existing in connection with nine-tenths of the habitations of the United States, were and are doubtless more injurious, even at the arm's length at which they were held, than are the average water-closets of average city houses. In saying this, however, it is not intended to be understood that these average modern appliances are acceptable as any thing but makeshifts—though relatively good, they are absolutely bad.

That their injurious effect on health is

practically as bad as theoretically it ought to be, is not obviously true. Many of their victims die in infancy, and so large a number of those who pass this critical period withstand their evil effects, that it has come to be believed by the people at large that the outcry against them is an unreasonable one.

Perhaps all popular outcry is unreasonable, but certainly those who will take the trouble to investigate the condition of the drainage of an average house, supplied with the usual plumbing appliances, will find defects at every turn—not merely slight defects which it would on the whole be better to avoid, but generally very grave defects which it is absolutely necessary to eradicate before we can hope to secure those conditions of perfect health which we have a right to demand of the civilization of which we boast. In periods of epidemic, or when cholera or yellow

fever is apprehended, the popular imagination on the subject becomes excited, and the long death-roll which pestilence creates gives an almost dramatic force to the stronger arguments advanced against our imperfect plumbing work.

As a matter of statistics, however, the deaths caused by any epidemic, and the degree to which these are favored by bad drainage, are of very secondary importance. The thousands of deaths from yellow fever in New Orleans, and in Memphis, and in the Mississippi Valley generally, in 1878 and 1879, fairly shook the country with terror. They amounted in all, in both years, to less than twenty thousand.

Their suddenness and their concentration gave them their striking effect.

In the country at large there are annually not fewer than one million deaths, and not fewer than two hundred thousand of

these are from directly preventible diseases. Not fewer than one hundred thousand of these latter probably owe their origin to diseases occasioned by defective drainage or to the improper retention of fecal matter and other organic wastes.

This enormous preventible death is, *from the point of view of the political economist*, only an index of something worse. Each preventible death doubtless represents, taking one disease with another, twenty cases of preventible sickness, and each such case of sickness implies at least twenty days of suffering and disability with its serious incidental cost in nursing and medication.

The real benefit, therefore, that is to accrue to the community from the establishment of perfect sanitary regulations, in the house and in the town, aside from the establishment of greater vigor and

efficiency, and of increased ability to withstand insalubrious conditions, is to be sought not so much in the prevention of these deaths as in the abolition of the diseases which cause them.

As in the town, so in the individual house, we shall be safe if our attention is given only incidentally to the saving of life, but directly to the preservation of health, *i. e.*, to the removal of all those conditions which affect the purity of the atmosphere in which we live, involving, of course, the purity of the ground on which our houses are built and the absolute prevention of the putrefaction any where within or near the house of its organic offscourings.

CHAPTER II.

DRAINS OF THE AVERAGE HOUSE.

A HOUSE completely equipped for convenient modern life has two systems, comparable to the arterial and venous systems of the living animal.

Its water supply is taken from the street main, or from the private reservoir or tank, and carried through tight pipes to the different points where convenience requires it to be delivered. This supply may easily be secured against contamination, and there is little trouble, if it is pure at its source, in keeping it pure until it is delivered for use. The venous system—that which has for its office the removal of the water after use—the

water supply *plus* the burden of filth which has been added to it—has its main discharge through the outlet drain.

The various points where the pure water is made foul are also conveniently distributed throughout the house. The drains begin usually as small lead pipes ; these lead to larger iron pipes and these to the main channel, sometimes of iron and sometimes of earthenware. The particular office which this venous system has to perform is to remove all of the refuse of the house which is suited for transportation in water. This office it usually performs with such a degree of completeness as to satisfy the average demand of the householder, *i. e.*, when water is discharged from a vessel it runs into the waste-pipe and is not heard from again. What becomes of it after it passes out of sight, whether or not it and its filth are really removed from the house ; whether or not

the removal is so rapid and complete as to prevent deposits and accumulations, are questions about which the average member of the community is heedless.

Lead pipes are usually tight. Iron pipes are connected together funnel-wise, so that whether they are tight or not the water runs away, and if the main drain does not carry to the outlet all that it receives, it leaks it out into the ground, where it is out of sight.

There is more or less unpleasant smell here and there and often a sensation of closeness about the atmosphere of the whole house. These attract little attention, because foul smells and closeness are generally accepted as a necessary incident of the production and disposal of filth.

It is precisely the conditions which lead to these more or less obviously disagreeable conditions which constitute the main feature of the practical sanitary question.

I have now in mind a large, elaborately decorated and richly furnished house in Fifth Avenue, New York, which I was called to inspect after a serious case of illness. The owner believed its drainage works to be all right. They had cost a very large sum originally and they had been repaired at considerable outlay.

Stationary wash-basins were distributed throughout the house. The spaces under them were closely encased in fine cabinet work. There were two bathrooms on each floor, containing the usual assortment of fixtures. The water-closets—their bowls elaborately decorated, some of them with gilt—were the usual “pan” closets of the period. Every pipe was concealed behind partitions, and all traps and machinery were covered under the floor or behind elaborate carpentry. The kitchen and pantry sinks

had waste-pipes two and a half inches in diameter, but were so filled with grease as to have but a thread of water-way left. The drains ramified in various directions under the floor of the cellar. These carried not only the wastes of the house, but the water from the roof. The waste-pipes in the house, in compliance with what was then believed to be the best practice, were vented with small air-pipes leading above the roof. There was no effective circulation of air in any part of the drainage system. There were evidences of positive leakage at many points, and the lines occupied by the supply and waste-pipes continued, in groups, through every floor, so that the whole house, behind the partitions and between the floor beams, constituted an unobstructed air channel from the ceiling to the garret. A stale odor was perceptible in all the passage-ways and closets and staircases,—

wherever the open fire places did not afford free ventilation.

It was demonstrated in the course of the inspection and renewal of the work, that the matters intended to be removed from the house were very largely only removed from sight. For lack of any thing like adequate flushing, the large waste-pipes and soil-pipes were lined with offensive slime; the kitchen and pantry sink wastes were nearly filled with putrefying food involved in the congealed grease that had attached itself to their walls. The drains under the cellar leaked at many of their joints so as to saturate and render foul the earth under the concrete floor. A direct opening into the sewer, intended to drain the cellar floor, protected only by a bell trap, from which the water had evaporated, was pouring into the air of the house as much foul gas from the drain as could get

past the accumulated dust and cobwebs by which it was nearly obstructed.

The chief complaint of the owner, and what he believed to be the source of all his woe, was that the public sewer was a foul one and that his house was pervaded with sewer gas. This may or may not have been the case. Whether it was or not, it was clearly demonstrated that there existed in the house itself, and almost throughout its whole drainage system, from the "container" of every water-closet, coated on the inside nearly half an inch thick with fecal matter, to the point where the main drain passed through the foundation wall—a more than ample source of all the difficulty.

Certain it is that when the work was reconstructed, though the sewer remained as before, the atmosphere of the house became, and still continues, perfectly pure.

The reconstruction of the work was sub-

stantially in accordance with the principles set forth in the following pages.

This is certainly not an exaggerated illustration of the condition of the drainage works of even the best houses of only a few years ago. Since then, not only has workmanship been greatly improved, but a number of radical modifications and reformations have been universally adopted. In some cities these reforms are enforced by rigid regulation of the health authorities. Nevertheless, a great majority of the houses in New York city as well as elsewhere are still in a very defective condition, and certain requirements, which the better sanitary practice considers important, are almost entirely absent.

The glaring mistakes of ten years ago are no longer repeated by reputable plumbers. The minor and more modern improvements which are still less gen-

erally appreciated will doubtless, before very long, be adopted into general practice, and the whole community will benefit greatly thereby.

It is still to be urged on every man and woman, who realizes the importance of perfection in this vital element of house construction, to anticipate the universal acceptance of the better processes and to insist that in their own cases at least, they shall be adopted forthwith.

The apprehension of cholera may stimulate attention to the subject, and that it may be urged on by each localized outbreak of typhoid fever or other zymotic disease is to be expected ; but much more than this is to be desired and to be advised, *i. e.*, to put the whole house into such perfect sanitary condition as to its waste-pipes, and as to its drains, that it can no longer by any possibility be a source even of the malaise, headache, dullness,

neuralgic affection, etc., which rob life of so much of its comfort and usefulness. One may properly recall in this connection Poor Richard's recommendation : Take care of the pence and the pounds will take care of themselves.

Look out well for the health-rate and the death-rate will lose its significance.

CHAPTER III.

THE POLICY HEREIN ADOPTED.

THE following chapters are presented as a simple and direct statement of some positive knowledge, and of more confident belief, about the drainage of houses.

They are not addressed to that indifferent public which sees a good deal of nonsense in the theories of all reformers. They are not addressed to plumbers, who, as a rule, are little attracted and less influenced by what is said by any body whose working years have not been given to plumbing work. They are not even addressed to architects and engineers, who, whatever their own convictions, when they have convictions on this subject, so often find it necessary to compromise with

their mechanics and with their clients, and to be content with such improvements as it seems under the circumstances judicious to insist on. They are addressed to that limited class who are willing to learn, and with whom a promising suggestion becomes a fruitful germ; to the few who will agree with their teachings, and to the more who will take their propositions into earnest consideration without the intention, and often without the result, of agreeing with them.

Where they can be avoided, alternative suggestions will not be made. If there are two ways of doing a thing, one right and the other only not wrong, the right way alone will be described. There is usually but one best way, and all that is to be considered here is purely and simply the best way of improving the drainage of a human habitation, and of maintaining its good sanitary condition.

CHAPTER IV.

THE HEALTHFULNESS OF THE HOUSE.

THE house, and the ground under and about it, and the air with which it is filled and surrounded, should be as dry and as clean as the best constant effort can make them. To this end, the most intelligent care and the most earnest attention must be given to all details of construction, and, no less, to the details of maintenance. No house, however perfect its original condition, can remain in perfect condition if subjected to the deteriorating influences of even ordinary carelessness.

Many a palace is a pig-pen in its hidden recesses, and where the light of day and the eye of a scrupulous housekeeper are withheld, there will those enemies of the

human race, dirt and damp and decay, surely make their stand. The whole range of cubby-holes, dark cellars, uninspected closets, and those spaces about pipes and fixtures which are screened from observation and withdrawn from the reach of care by the pernicious carpentry to which the plumbing art is so closely wedded, are, all of them, places to be suspected and as far as possible to be abolished. Where dark places must be maintained, they should be the chief objects of the householder's care. It is a wise old sanitary saying that "where daylight can not enter the doctor must."

Houses that are perfect, even in the general arrangement and construction of their drainage works, are extremely rare. Those which, having begun perfect, continue so under daily occupation, are still more rare. So true is this that it is sometimes asked if it is, after all, worth while

to encounter the additional expense and the constant attention that perfection demands ; whether, indeed, the world has not got on so well in spite of grave sanitary defects that it is futile to hope for an improvement corresponding with the cost in money and time.

The most simple and the sufficient answer to this is that the world has not got on well at all, and is not getting on well ; that among large classes of the population one-half of all the children born die before they attain the age of five years ; that those who come to maturity rarely escape the suffering, loss of time, and incidental expense of unnecessary sickness ; that the average age of all mankind at death is not one-half of what it would be were we living under perfect sanitary conditions ; that one of the chief items of cost in carrying on the world, to say nothing of the cost of bury-

ing those who die, is that of supporting and attending the sick and helpless ; that another great item is the cost of raising children to, or toward, the useful age, and then having them die before they begin to make a return on the investment ; that the great object of a well-regulated life is to secure happiness for one's self and for one's dependents, an aim which is crushed to the earth with every death of wife or child or friend.

There is a sentimental view, no less important, which need not be recited, but which is sufficiently suggested to the minds of all who have had to do with the sanitary regulation of houses by the frequency with which their services are called into requisition only when the offices of the undertaker have been performed. No cost and no care would be too great to prevent the constantly recurring domestic calamities which have had

their origin, and which have found their development, in material conditions that a little original outlay and a constant and watchful care would have prevented.

The objects to be attained in the drainage of a house and of its site are, first, to remove all causes of excessive dampness ; and, second, to provide a means for the water transportation of organic wastes to a safe point of disposal, in such a way as to prevent decomposition on the premises, and so as to exclude from the house all air which has been in contact with these matters after their discharge into the drainage system.

The means for accomplishing these ends are of two distinct sorts : one allied to the drainage of agricultural lands, the other to the flushing of gutters.

CHAPTER V.

FOUNDATION AND CELLAR.

THE first in order of execution, and although not first in importance, still of absolute importance, is the work for preventing undue dampness of the interior atmosphere, or of the walls, of the house by an actual inflow of water, by an exhalation of vapor from the water contained in the soil, or by a soaking of the foundation. In the case of city houses occupying the whole width of the lots on which they stand, this drainage is necessarily confined to the cellar and foundations, and, as a rule, the water to be drained away can be delivered only into a public sewer—though there are frequent

exceptional cases where, by piercing an impervious stratum of clay or other material, an outlet may be gained into a porous stratum of gravel or sand below.

Wherever the site is on a deep and naturally well-drained bed of sand or gravel, the question of drainage as a means for removing soil-water does not present itself. But here another very serious difficulty is to be encountered, having a different sanitary bearing, but of no less sanitary consequence. This relates to the protection of the house against exhalations from the ground—not of moisture, but of the atmospheric impurities of the subsoil.

In the case of a country house, or of a town house standing in the center of a considerable area, it is often the most efficient means for securing satisfactory drainage to apply a very thorough system of underdraining to the whole area about

it and for some distance away, by laying independent lines of tile drains, not necessarily under the house at all, but so as to surround it on all sides from which water flows toward it, and in all cases at a depth several feet below the level of the cellar-bottom.

It is seldom, even where a spring is struck in digging the cellar, that such drains, surrounding the site of the house, will not entirely divert the water. In this drainage of large lots, the character of the outlet is of secondary importance. All that is needed is that it shall be low enough for the free discharge of the flow of the drains. If the discharge be into a sewer, the drains should descend toward it with a sufficient fall to prevent foul water from setting back into them in the case of a gorging of the sewer at a point near the house.

In the drainage of a city house occu-

pying the whole width of the lot, the same system is to be adopted, save that the drains, instead of being so placed as to surround the house and cut off water approaching it, must perforce be placed under or near the foundation to receive such water as may have reached its actual site. Here the question of outlet becomes a serious one. If the discharge must be into a sewer, then some special means must be adopted for preventing the return of the air of the sewer to the subsoil under the house.

In the construction of these drains two courses may be pursued with perhaps an equally good result. One is, after having excavated the ditch and cleared its bottom of all loose dirt, to fill in to the depth of a foot with sand or gravel—and even fine sand will answer the purpose. The other is, to use agricultural drain-tiles, preferably of the smallest

size, say an inch and a quarter in diameter, laid at the bottom of a well-graded trench and continued to the point of outlet.

Where tiles are used, the joints should

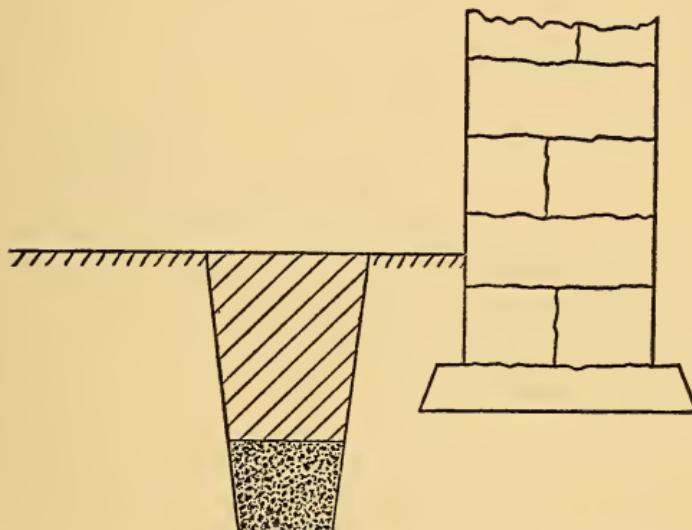


FIG. 1.—GRAVEL DRAIN, UNDER CELLAR FLOOR, NEAR FOUNDATION.

be wrapped twice around with strips of muslin drawn tight. This makes a perfect collar, holding the tiles in line, and affording much the best protection that has yet been devised against the ingress of sand or silt, which usually

finds its entrance at the lower part of the joint, flowing in with the water as it rises with the general water-level and flows off over the floor of the tile.* Before the muslin will have rotted away the soil will become so compacted as not to follow the water into the tiles.

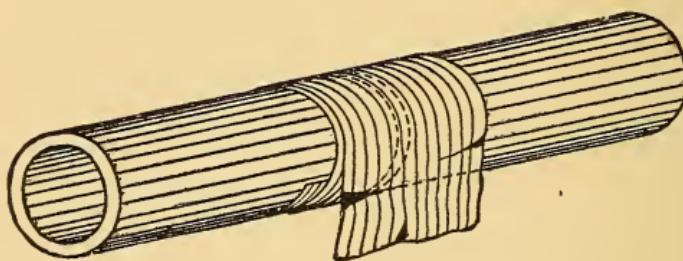


FIG. 2.—THE DRAIN, WITH MUSLIN JOINT.

Where tile drains are used, it is a mistake to marry them to other materials. Tile alone or gravel alone will make a very good drain—tile and gravel together, not nearly so good when per-

* This use of muslin is patented, but it is hereby dedicated to the public to the extent of its use under or within the foundation-wall of buildings.

manence is considered. Tiles should be laid on the bottom of a perfectly graded ditch, and should be compactly imbedded in the heaviest loam that is found in excavating. When covered to the depth of a foot, this clay should be well trodden down, so that if the tile could be taken out, leaving the earth undisturbed, we should find a complete matrix, or *nidus*, which had clasped it firmly at every point. The old marvel, How gets the water in? is too long for discussion here. I beg the reader to take the word of an old drainer that it does get in—and get out—perfectly.

The large pipe drains with wide joints, often with fractures giving access to vermin—no less than the “box drains,” “French drains,” “blind drains,” and various other antique devices for getting rid of soil-water—are costly, cumbersome, and in the long run, inefficient,

owing to their liability to obstruction. The amount of water that can ever be collected as a constant stream, except in the case of a very copious spring, even in very wet foundations, is extremely slight. A sand seam in the natural soil one-fourth of an inch thick is generally sufficient to carry it; and it is such seams, carrying water in a slow but constant ooze, which usually produce our subterranean and surface springs.

A tile an inch and a quarter in diameter will carry more water than can often be collected for a constant flow from the subsoil of half an acre of ground. A body of sand or gravel ten or twelve inches wide and of equal depth can not be so compacted, provided clay and loam be kept out of it, and it will not afford a free outlet for all the water that can reach it under these circumstances from the soil of an ordinary town lot.

As a rule, the tile will be found to be much cheaper than the other material. It is better always that the depth of the drain should not be less than two feet below the level of the foot of the foundation. The more rapid the descent the better, but even two inches in a hundred feet, with perfect grading, will remove a very large flow. Indeed, if the drain has no fall, or even if it be depressed in places, provided it have a good and unobstructed outlet and well-protected joints, its surplus water will be discharged as soon as the general level of the water reaches the overflow point.

Where the water is to be delivered to a sewer, I should in any case recommend the making of the outlet drain, or a part of it, with sand or very fine gravel. I should at least make a break ten feet long in the course of the drain, and fill this with such material—fine enough not to

allow the free transmission of sewer air to the drains under the house, which a continuous tile drain would permit. I am aware that this recommendation is radically different from what has generally been set forth; but it long ago commended itself to my judgment, and has proven in practice to be entirely successful.

It is a usual custom to connect the underdrains of a house with the drain carrying the foul water, and to connect with them, also, the rain-water conductors from the roof. In view of what we know of the ease with which the contained air of the subsoil may be contaminated, it is of the utmost importance, where the best results are sought, to deliver the underground water itself by an independent line guarded with absolute completeness against the possible invasion of sewage or foul air. Nowhere within the house, nor,

indeed, for some distance outside of it, should even the rain-water conductors deliver into this system.

By the means just described, the actual superabundant water of the soil may be removed.

In connection with the foundation and cellar, two things else demand attention. The first is the carrying up of dampness through the foundations into the walls of the house, and the exhalation of watery vapor, which, in the case of a heavy soil, however well drained, is of considerable amount. These difficulties attach chiefly to clayey ground. The next is the entrance into the house of the aerial exhalations of the soil.

Even a clay soil contains a large amount of air, and under different circumstances, such as changing barometric pressure, the rise and fall of water in the soil, and the action of winds,

producing a strong draught in chimneys, this air enters the cellar and the house. This difficulty, not serious in the case of stiff clay, increases greatly as the soil grows more porous and becomes more dry. For example :

A pile of stones broken to the size of road-metal contains a very large amount of air,—how large we could determine by filling the voids with water and measuring its quantity. Every wind that blows, every change of temperature, every rise of water into the mass, drives out or changes a portion of this air. If at the bottom of the heap there lay a mass of carrion, its stench would be almost as perceptible as though the stones were not there. A bed of such stones sufficiently large and sufficiently compacted would make a dry, firm, safe foundation for a house—in many respects an excellent foundation.

But if the atmosphere of the house were not separated from that of the interior of the mass of stones by something much more effective than even the usual cellar-bottom concrete, and if the carrion were putrefying beneath, the state of things would not be the worst possible only because the obvious offensiveness resulting from the putrefaction with the free interchange of atmosphere between the house and the foundation would insure the immediate removal of the cause of the stench.

This mass of broken stone, with its putrefying carrion below and its human habitation above, is only an exaggerated illustration of what exists universally over wide ranges of country. Houses are sometimes built on coarse gravel. Here the atmospheric interchange is almost as free as in the illustration given. Sometimes the gravel is finer and mixed with

sand which, imposing by friction more resistance to the movement of the air, limits the interchange; but interchange to the extent of free inhalation and exhalation always goes on. Nothing can prevent this from being active when chimneys are drawing strongly, while the house is sealed against the outer air; when, indeed, as is so often and so widely the case on light soils, the whole practical ventilation of the house—that is, its intake of air—is from the ground under it, often flowing through and enriched by the various familiar fumes of ill-kept cellars.

The putrid carrion, it is true, we do not find in such concentrated condition as to produce an insufferable stench; but let us examine the case of a certain village. It is not necessary to name it. There is not a State in New England in which many of its parallels may not be found,

and, indeed, there is hardly a village in the whole country built on a porous soil where corresponding conditions do not exist.

The village that I have in mind was built on a flat deposit of gravel intermixed with very coarse sand, lying nearly level and extending in depth about fifteen feet to the permanent level of the adjacent tidal waters. It was a considerable village throughout the first half of the century; then it began to expand into an important railroad town. It has now a large population and much wealth. It has a water supply, and "all the modern improvements"—all except sewers. Its disposal of household waste of all kinds is not *upon* the soil, which would be obviously indecent, but *into* the soil, which has the supposed advantage of hidden indecency.

The result must inevitably be a diffusion throughout the whole underlying ground-

work of the village of putrefying kitchen grease, and fecal matter and laundry slops, which can not fail to produce in the whole atmosphere of the gravelly earth a condition of marked contamination. Even in the milder season, however free the interchange between the air in the ground and the air over it, the air of so much of the ground as lies under houses can not be by any means ideally perfect. When the interchange between the outer air and the ground is cut off by frost, and when cellars and wells form almost the only means of communication, then the condition is only infinitely worse.

This description may seem at first reading too sensational, and dwellers on light soils will point with satisfaction to the relatively low death-rate that their communities furnish as contrasted with that of dwellers on damp clay soils, where this atmospheric interchange is practically in-

operative. This is no fair response. The death-rate is comparatively low under these circumstances, not because of, but in spite of, the almost universal breathing of the products of putrefaction as exhaled by the soil into the house. Could this element be withdrawn, it can not be questioned that, on the lighter soil, the death-rate, and in larger degree the sick-rate, would show a much greater contrast.

The practical question now arises, how to meet this difficulty? If proper sewers were once provided, an absolute suppression of all vaults and cesspools would suffice to secure the early purification of the ground, for the bacteria of putrefaction—those universal scavengers—would soon make away with the existing accumulation. How far their action may modify the present ill effects of the constantly renewed underground filth we have as yet no means of knowing. If we are wise we

shall take the benefit of the doubt and cut off the supply of foul material.

Sooner or later, we shall secure, by sewerage and a compulsory use of the sewers, the complete purification of the subsoil. In the meantime, the individual householder who has an anxious thought as to the condition of his individual house, and who is now living subject to the influences of an evil due to his neighbors' many cesspools more than to his own single one, should seek some means to protect himself against enemies which his neighbors are willing to disregard. He will find his best protection in isolating his house in the most effective way from the ground in which it is founded. There is a common belief that stone walls laid in mortar, and cellar floors covered with a few inches of concrete, effect such isolation. This is not the fact. Concrete floors and granite walls are as sponge to

the penetration under slight pressure of atmospheric currents. To what degree walls and concrete floors filter out the impurities of the air passing through them we do not know. Not knowing, we will not trust.

One of the safest materials for a cellar bottom, and for the exterior packing of foundation walls, is a clean, smooth, compact clay, one which may be beaten into a close mass, and which has a sufficient affinity for moisture always to maintain its retentive condition. When used in the damp atmosphere of a cellar or about a foundation, it seems to constitute a good barrier to the passage of impure air. In the cellar it may, of course, be covered with concrete for cleanliness and for good appearance ; but six inches of clay well rammed while wet will impede the movement of air to a degree with which ordinary cellar con-

crete can furnish no parallel. Where clay is not available, a good smearing of asphalt over the outside of the foundation-wall, and a layer of asphalt between two thicknesses of concrete for the cellar-bottom, will afford a complete though more costly protection. Asphalt used in substantially the same way, especially if in connection with a solid course of slate or North River bluestone, in the foundation above the ground level, will prevent the soaking up into the structure of the moisture of a heavy soil.

The matters above touched upon are seldom discussed in works on house-drainage, except so far as the mere removal of surplus soil moisture is concerned, but their importance is not likely to be overestimated.

There may be good grounds for the opinion of those who think that many of the minor ailments to which the

race is subject, and some of its more serious ailments as well, are due, not to the influence of an excess of filth in any form, but to the influence of an excess of moisture acting often on a little filth, or on a little organic waste which would not be classed as filth at all. Such ailments prevail more especially in houses in which mold is prevalent, which on being closed soon acquire a musty smell, and in which stuffiness is a natural condition—houses where a general and all-pervading slight dampness is to be detected. This dampness may belong to the structure rather than to the climate; for there are dry houses at the sea-side and damp houses on the mountains.

The soil has an influence over the interior climate of the house, which is even stronger than external atmospheric conditions. Positive knowledge does not carry us very far in this direction,

but the experience and observation of the world, especially where intermittent fevers and neuralgia prevail and where an ailing condition and low tone are the rule, have indicated very clearly that the wisest course for every man who would make his home perfectly healthy would be to separate it as completely as possible from all interchange of air or moisture with the ground on which it is built.

CHAPTER VI.

FOUL DRAINAGE.

A NOTHER and even more important branch of house-drainage has come into general use within a comparatively short time. This is now attracting quite all the attention that is its due. Knowledge concerning it is advancing steadily, and on the whole satisfactorily. Mistakes have been made during the past dozen years even by the best of those who have had to do with it. Such mistakes have from time to time become recognized, and they have been remedied, until we are now approaching something like a fair understanding of the fundamental requirements of house-drainage. Perhaps it would be too much to say that the practice of the art keeps any thing like

even pace with the knowledge as to its principles.

Neither the common usage of the best plumbers nor the average requirements of the boards of health of cities show any very considerable improvement over what was done in the better work of some years ago, save in better workmanship.

Leaky joints in iron pipe, though still by no means uncommon, are less frequently found since attention has been given to testing joints under pressure. In the best work, the thorough ventilation of soil-pipes, furnishing an inlet as well as an outlet for the movement of air, is now generally adopted. Another step in advance is marked by the abandonment or the much better construction of drains laid under cellar-bottoms.

The greatest step of all—the step which insured wide public benefit—was taken when municipal boards of health became

so generally, so almost universally, interested in the subject of plumbing regulations. These bodies have nearly everywhere established an effective control over all new work done, and often over the amendment of old work. The main point being gained, that all such work is to be executed according to rules and under such inspection as will secure the observance of the rules, it is only a question of time when the rules themselves shall be perfected.

As they stand, these plumbing regulations permit some things which they will hereafter prohibit, and they require some things which they will hereafter, perhaps, not permit. In the latter category is the back ventilation of traps, and in the former the use of "pan" water-closets, of fresh-air inlets at the level of the sidewalk, and of bends, cowls, and caps at the top of the soil-pipe.

However, in spite of all their imperfections, the establishment of such regulations, and the rigorous enforcement of their requirements under actual inspection, have marked the greatest progress that has been made for a long time past. It is to be remembered, in criticising these regulations, that they are necessarily made suitable for universal application. They are a very inadequate guide for the arrangement of the plumbing work of a large and elaborate house ; but they do constitute an invaluable guide and safeguard for work of a cheaper sort. The poor tenant, who was formerly at the mercy of his landlord, is now protected by a system which must inevitably prevent the repetition of the infamous work of the cheap plumber of a few years ago.

CHAPTER VII.

SPECIFIC ADVICE.

IT is no part of the purpose with which this book is written to discuss, even in a general way, the different methods and processes of house-drainage, nor the various theories and opinions by which different writers on the subject are influenced. It will be assumed that the reader will be satisfied to find here only the writer's own opinion, and a statement of the grounds on which that opinion is based. I shall therefore confine myself to saying what I advise doing, with the reasons therefor.

I advise, above and before all, that in every house, large or small, the *amount* of plumbing work be reduced to the low-

est convenient limit; that there be not two sinks or water-closets or bath-tubs where one will suffice for reasonable convenience; that under no circumstances shall there be a wash-basin or any other opening into any channel which is connected with the drainage system, in a sleeping-room, nor ordinarily in a closet opening into a sleeping-room. I should confine all plumbing fixtures on bed-room floors to bath-rooms.

I should give each bath-room exterior ventilation, but I should never locate its pipes against an outer wall unless I could give adequate protection against frost, for the liability to danger from the freezing of waste-pipes, traps, etc., is greater than the liability to danger from an interior location—if the fixtures are all of the best sort, and if the room itself is sufficiently ventilated.

I should always, so far as possible,

place the bath-rooms so nearly over each other on different floors, that they could all be connected by short waste-pipes with one vertical soil-pipe, or so that the soil-pipe could reach them with short offsets. If bath-rooms or water-closets were required on all floors, or on any floor, in different parts of the house, I should serve each set with its own vertical soil-pipe, avoiding any considerable horizontal run, such as is at times resorted to in connecting fixtures at different points on different floors.

I should try, so far as possible, to have every part of the plumbing work fully exposed to sight. It is occasionally necessary to run a soil-pipe or other waste-pipe in a position where it ought to be concealed ; but I should, when I could, avoid such situations, and when possible I should resort to some frank decoration of the pipe rather than to its concealment behind a casing.

Wherever pipes pass through floors in going from one story to another, I should make an absolutely tight blocking of the channel. As generally arranged, the soil-pipe and other pipes run through bungling openings in the floor concealed behind carpentry of one sort or another, and the pipes themselves are boxed in so that the whole system constitutes a free run-way for vermin, and a free channel for the diffusion from cellar to garret, and between floors and behind partitions, of whatever foul air an ill-kept cellar and closet-fixtures may produce.

The diffusion throughout steam-heated and ill-ventilated rooms of the floating results of hidden decomposition is apparent to a fresh nostril in many a "first-class house." There is no minor item connected with house-drainage that is productive of such an obvious improvement in the atmosphere of the rooms as the shutting off of this means of intercommunication.

I should use only extra-heavy soil-pipe, or pipe at least with extra-strong hubs, so that the lead calking can be driven so tightly home as to make leakage under any pressure absolutely impossible.

I should try to avoid the placing of plumbing fixtures of any sort in the cellar of a house, unless they could so be arranged as to deliver into a soil-pipe or drain not concealed under the floor. In exceptional cases, where an underground drain is necessary, I should not follow the regulations and lay a mason-work trench with a movable cover, so that access to the pipe could be gained at pleasure. I should have the pipe laid in an open trench, and so thoroughly calked that under a pressure equal to the height of one story not a drop should escape at any joint; and then, a safe conduit being secured, I should inclose it in a concreting of the best cement, embracing

it so completely and so securely that if the iron should rust out and be washed away, the cement itself would constitute a safe channel.

I should make it a chief aim to secure for all needed fixtures the greatest simplicity, and for all waste-pipes the greatest absence of complication. I should use sinks without grease-traps, bath-tubs without inaccessible overflows, wash-basins free as far as possible from fouling places, and water-closets without valves, connecting rods, or machinery. Such restriction would limit very materially the range of selection, and would lead to discarding many things that are now in common use.

This suggestion is a radical one, and it will fail of acceptance in many most respectable quarters. There can be, however, no question as to the propriety of expressing one's firm con-

victions in the most distinct way. What I am endeavoring to convey is not the well-known average opinion of engineers and sanitarians—only my own opinion. This may be entirely wrong; but it is the outgrowth of the best thought that I have been able to give the subject, and it must be conceded that no harm will result to the health of the people if it is followed out in practice.

CHAPTER VIII.

THE SEWER-GAS QUESTION.

THE main purpose of house-drainage, as we now understand it, is to remove all such wastes of domestic life as are suited for transportation in running water with the greatest completeness and with the greatest attainable safety. To secure this object, the drainage system must be so constructed as to carry away, completely and immediately, every thing that may be delivered into it; to be constantly and generally well ventilated; to be frequently and thoroughly flushed; and to have each of its openings into the house guarded by a secure and reliable obstacle to the movement of air from the

interior of the drain or pipe into the room.

It is no longer a question of "sewer-gas." Wherever the offensive exhalations designated by this term exist, wherever the effluvium of putrid waste may be detected, there is inevitably defective arrangement, or defective workmanship, or both.

It is no longer to be considered the best policy to shut off sewer-gas from the house by confining it to the sewer. The true course should be to seek the seat of the evil and to remove its cause.

The foul air in a defective sewer or in a defective house-drain—and it more often originates in the latter—is invariably the result of the accumulation and retention of filth—its retention for a long enough time to allow it to enter into putrid decomposition. There is but one proper way to cure it; that is, to prevent

the accumulation. Such removal is to be secured only by thorough flushing, either by a copious stream accompanying the discharge, or by frequent periodic washings sufficient to sweep all deposits away. No flushing will prevent some sliming of the pipes, but good ventilation will take care of this.

All drains, soil-pipes, and waste-pipes should be absolutely tight, not only against the leakage of liquid, but against the leakage of air; they should be so reached, in every part, by a flushing stream of one sort or another, that deposit and accumulation will be impossible; they should be as thoroughly ventilated in every part as the safety of the water-seal will permit. The exterior drain, and ultimately the sewer into which it delivers, should have the same general characteristics, it being understood that the freest possible ventilation

is to be given to both sewer and house-drain, by the admission of air from without and the delivery of air to the open sky, without the possibility of its entering the house at any point, in any manner, or at any time.

All fixtures should be so trapped that the exclusion of the air of the drain should be assured, but at the same time in such a manner that at each use of every fixture all the filth that it delivers shall be carried completely away, the trap being immediately refilled with fresh water.

Such are the leading sanitary requirements of house-drainage. These being secured, it is a matter of little sanitary consequence whether the fixtures themselves are cheap or costly, simple or elaborate, ornamented or plain. As, however, these appliances are devoted to the meaner uses of the household, good

taste would indicate that their most appropriate “elegance” is to be secured by making them and their belongings as simple as possible, and as inexpensive as the securing of the best results will allow. They should be conspicuous, if at all, by their purity and cleanliness.

Having thus set forth the general principles that should govern the construction of the drainage work of houses of all classes, we may next consider its details.

CHAPTER IX.

HOW THE SIMPLIFICATION OF PLUMBING WILL AFFECT THE PLUMBER.

A CHIEF obstacle to the simplification of the plumbing works of a house arises from the mistaken commercial instinct of the plumber. It looks at first blush as though any thing tending to cut down the amount of their work must be injurious.

So far as the present force of good plumbers is concerned, it seems to me that their business interest lies entirely in the other direction. New houses are being built with great rapidity and old houses are having their plumbing work rearranged more and more thoroughly every

year. Certainly the work is increasing much faster than is the number of plumbers qualified to do it properly.

If the present profusion of plumbing appliances is adhered to, the only possible way in which construction and repair can be done will be by increasing the number of plumbers, faster, much faster, than material for the making of *good* plumbers will present itself.

Of course, the number of men engaged in this handicraft must increase constantly, but the more the amount of work in each house can be reduced the better and longer hold will the present force of good master and journeymen plumbers and the well-trained future addition to that force be able to do all of the good work offering within their reach. They are suffering now very greatly from competition with inferior and unprincipled men. The more rapidly the amount of work to

be done increases, the more will this competition work to their disadvantage.

If this suggestion is sound, the best course for the better plumbers to adopt in the interest of their own business will be to approve of and to recommend such a reduction of the amount of work in each case as will enable them to manage the growing number of cases.

It is appropriate in this connection to offer a distinct recognition of the fact that practically, so far as the interests of the whole people are concerned, the plumbing fraternity are by far the most influential of all house sanitarians. Engineers, physicians and health officers accomplish much by their influence with individuals, and by the exercise of their professional and official functions ; but they reach after all only a limited section of the community. The plumber on the contrary makes his influence felt on every hand. Where an

engineer or a sanitarian has to do with the drainage of one house, a plumber in good practice has practically the absolute control of a hundred houses. Ninety-nine men out of one hundred would receive the suggestion of a theoretical sanitarian in a very gingerly way, while they would accept without question the dictum of a practical plumber.

Plumbers of the better class are fast coming to recognize the fact that the prosperity which this popular confidence brings to them, carries with it a serious public responsibility — a responsibility which, as a rule, they are endeavoring to meet in a spirit that is at least rare with men of other crafts. It is not universal with them.

Another responsibility falls upon those who undertake to instruct architects, house-owners, and plumbers themselves as to the proper management of house-

drainage, i. e., the responsibility that attends an interference with plumbers' work. It is not only important to prescribe what should be done, but it is important to do this in such a spirit, and with such clearness, as to carry persuasion and conviction to the minds, and to engage the willing interest, of these ubiquitous guardians of the health of the household. It is mainly because of this responsibility that I am anxious to assure those whose interests lie in the construction of house-drainage works that the simplification of drainage systems which I so earnestly advise is in no respect inimical to the best business interests of the trade.

CHAPTER X.

THE MAIN LINE AND MAIN TRAPS.

IN arranging the details of house-drainage the main line is always first to be considered. It begins at the sewer, or flush-tank, or—in barbarous instances—at the cess-pool; passes through the house by such a course as may be indicated by a judicious compromise between directness and convenience, past the location of the highest fixture that is to discharge into it, and then passes out through the roof for free ventilation.

The question of a main trap between the house and a public sewer has been much discussed, and is still determined by no rule. There should always be such

a trap between the house and a flush-tank or a cess-pool. I am inclined to the belief that there should not be such a trap in the case of discharge into a sewer, unless it be especially foul. If it is only a great cess-pool, holding the accumulated deposits of a street or larger district, or if its interior atmosphere is at all comparable in offensiveness with that of a cess-pool, then a trap will be desirable ; but if it has such an atmosphere as will admit of the entrance of workmen, and if its contents are carried forward in its current with reasonable completeness, I incline to the opinion that, even if no other house connected with it aids in its ventilation, it will be better that the single house under consideration should be connected without a trap.

I have reached this conclusion slowly and in opposition to the opinion of many of the best engineers. The objections

ordinarily raised against the practice are that by it “ the sewer-gas is laid on ” to the house ; that contagious diseases existing in other houses connected with the sewer will communicate their infection directly to any house not so cut off ; and that, as a matter of common policy, one man alone should not ventilate a sewer that is used without ventilation by neighbours.

There are two arguments against this, and they seem to be controlling ones. (a.) The purpose to be secured is the greatest practicable purity of the drains and pipes of the particular house, and, while it is true that a trap will shut off the air of the sewer, it is also true that the trap itself, unless the course of the drain is very steep and its flushing very copious, may not only form a seat of decomposing filth, but will so set back the flow as to cause a deposit of foul material for some dis-

tance along the drain on the house side of the trap.

If the sewer is not extremely offensive—more offensive than a critical investigation made a few years ago showed most sewers in New York city to be—there will be less stench coming from a current of air flowing from the sewer without a trap than will be developed in the house-drain itself with a trap. The absence of the trap will secure a pretty constant and effective current of air from the sewer through to the top of the soil-pipe. Without the trap, a sufficient current can be established by the use of a well-placed fresh-air inlet; but the immediate seat of decomposition in and behind the trap will continue active.

(b.) All the cry about sewer-gas being "laid on," and about the intercommunication of diseases from one house to another by means of the sewer, is the out-

growth of a condition that is now hardly tolerated, and that certainly is not contemplated in this paper. In the older work, there was either no ventilation whatever to the drainage system of the house or it was very inefficient. The water used, though perhaps not less in amount then than now, was not so used as to secure a good flushing effect, while the stability of traps was then little thought of.

Pressure of any sort being brought to bear on the atmosphere of the sewer, foul air escaped into house-drains and found no other means of relief than by forcing traps or by working its way out at defective joints. Under such circumstances, the argument in favor of the trap was a strong one. Now, house-drain and soil-pipe are tight, ventilation is very free and complete, the effect of a pressure on the air of the sewer is not to be feared, traps

are reliable, and, in the best work, joints are absolutely tight.

Under such conditions the safeguard supposed to be furnished by the exterior trap is not needed—assuming always that the sewer is a reasonably clean one. Its condition will always be improved by the ventilation furnished by the untrapped drain.

CHAPTER XI.

FRESH-AIR INLETS.

IN the case of country houses, not discharging into sewers, the trap is a necessity. Wherever a trap is used, there must be on the house side of it an inlet for fresh air. There can be no real ventilation of the drainage system if it is open only at its top. A bottle can not be ventilated by removing its cork, nor will a chimney draw if it has no opening at the bottom. A copious inlet for fresh air, working in conjunction with a wide opening at the top of the soil-pipe, will insure a free movement throughout the whole system that will accomplish an adequate ventilation, not only of the main channel

itself, but, by the diffusion of gases, of *short* branches connecting fixtures with it.

Most of the directions given in sanitary journals and books for the arrangement of fresh-air inlets, especially in cities, seem to have been made without due regard to their liability to become obstructed by rubbish, and especially to become entirely closed by accumulations of snow. Many such inlets in New York, at the edge of the pavement or at the face of the curb, are sometimes blocked for days together in bad winter weather. Becoming obstructed from any cause, their efficiency stops, and for the time being the security that they should afford is withdrawn.

There is really no good reason for placing this opening at a distance from the house. I have never known annoyance resulting from the inlet pipe being brought out at the face of the foundation wall, preferably, of course, not too near

to windows and doors. With well-flushed pipes, as already said, the constant though often slow movement of air through them so reduces the offensiveness, which a few years since was thought to be inevitable, that, although there might be a slight outward puff when closets or baths are discharged, no annoyance results.

CHAPTER XII.

MATERIAL AND CONSTRUCTION.

WHETHER the soil-pipe passes through or under the foundation of the house, unless the wall be old enough for all danger of settlement to have passed, it should be carried through an arched opening to prevent its disturbance if settlement does occur. In any case, the iron pipe should be continued for nearly or quite a full length (five feet) outside of the foundation wall. It may be continued further with advantage. Although thus laid in the ground and used as a drain, iron pipe is not, like earthenware pipe, imperishable; still the greater certainty of tightness, and correct

grading, if due only to the better class of workmen by whom it is done, is a strong argument in its favor. After reaching solid ground that has not been disturbed in excavating for the foundation, *a carefully laid and rigidly inspected* earthenware drain is to be preferred.

After the drain passes inside of the foundation wall it is better, where it is not necessary to connect with fixtures in the cellar, that it should be carried in full sight, along the face of the cellar wall or suspended from the floor-beams, to the point where it is to turn up as a vertical soil-pipe. This is advisable because here as much as any where else in the house, it is important to be able to inspect the joints, and to know always the condition of the work.

If, however, it should be necessary to make connection with a water-closet or other fixture in the cellar, it is better that

the main channel should run under the floor to or near the location of such fixture, in order that all or nearly all of its length may constitute a part of the main line, thoroughly flushed and thoroughly ventilated, like the rest of the system.

If there are several vertical soil-pipes, it will suffice, of course, if one of them is carried down for the cellar connection, and the others can be carried together above ground and connected with the main line before leaving the house. A branch only ten or twelve feet long, running to a servants' closet in the cellar, even if provided with adequate upward ventilation, is not likely to keep in nearly so good condition as it would if carrying also the discharge of closets and baths above.

Whenever it becomes necessary to lay the drain under the cellar floor, I should *not* counsel the following of the usual recom-

mendation to lay an iron pipe in a mason-work trench, with a cover that may be removed for inspection. It should be protected as hereinbefore described.

CHAPTER XIII.

THE SOIL-PIPE.

IT is a generally accepted rule, and a good one where space suffices, to use no short turns—technically, “T branches” and “quarter bends.” Two one-eighth bends, or a Y branch and a single one-eighth bend, give a more gradual and therefore better change of direction. So, in the attachment of water-closets to vertical soil-pipes, it is usual and better to make the connection with Y branches. Where space does not suffice, however, a half Y answers a sufficiently good purpose, and even a T branch (right angle) is less objectionable than it was when

flushing was less copious than now. The soil-pipe throughout its whole length, horizontal as well as vertical, should be so secured with hangers and clamps or hooks and with supporting posts that it will be rigidly fixed in its position.

From the beginning of the work, every joint should be made with a view to being tested under hydraulic pressure. If the workman has this in view, the test will generally discover few leaks. As ordinarily made, especially where the whole circumference of the pipe is not easily accessible to the calking tool, a test will almost invariably disclose serious leakage.

In every case the test *should* be made, and every semblance of a leak should be calked until thoroughly tight under pressure. In making this test, the simplest way is to close all openings into the pipe with disks of india-rubber compressed between two plates of iron forced together

with a screw. Such plugs can be fastened so tightly as to hold a head of fifty feet. There is no special advantage, however, in applying this force; for if joints are to leak at all, they will leak usually under a head of a few inches, and always under a head of a few feet. It is generally most convenient to test the vertical pipes story by story, the plugs being inserted through the water-closet branches.

Another satisfactory test which may be applied after all fixtures are attached, is made with an air-pump and pressure-gauge, such as gas-fitters use. If the gauge stands firm even under a slight pressure for an hour together, the work may be accepted as tight. The principal drawback is that, if the joints are not tight, it is much more difficult to locate a slight leak than when the water test is used.

I think it may be accepted as a well-

grounded rule that no prudent owner should receive and pay for his plumbing work until all of the iron waste-pipe has been tested, by one or the other of these methods, under the personal observation of the architect or his plumbing expert. There is probably no occasion to fear that work once made tight will develop leaks for many years, the tendency to rust after a time, even with tar-coated or enameled pipe, being rather to close such slight leaks as may exist.

The fear has sometimes been felt that sand-holes and slight imperfections in cast-iron soil-pipe may lead to the permanent injury of the work. Ordinarily, this is not a real danger. Where pipes have been tested before erection by being filled with water in single lengths and rejected because of slight leaks, it has been found that a few hours later such leaks have become entirely closed with

rust. Doubtless a rust closure is a permanent one.

I am now experimenting with a soil-pipe joint which promises to be successful. It is a turned or ground joint, which is hermetically tight when first put together or which in a very short time becomes so from rusting

These experiments are not yet quite so far advanced that it would be expedient to describe here the details of the method.

There are two grades of soil-pipe known to the trade, "common" and "extra-heavy." If common pipe has sufficiently strong hubs to stand heavy calking, *and if the outer and inner circumferences are concentric*, there is no reason why it may not be trusted for very long service ; but it is difficult to maintain the core in a perfectly concentric position, and even in the best pipe there is generally a slight difference of thickness

between one side and another. A very slight difference is a serious matter in common pipe. In extra-heavy pipe, unless the eccentricity is very obvious, even the thinner portion will be thick enough for safety. This thicker pipe, however, is sometimes weakened by air bubbles in the mass. To detect these, the pipe should be tested by sharp hammering over its whole surface.

In ordinary work in private houses, a diameter of four inches has been adopted as sufficient for the soil-pipe. So far as the mere water-way is concerned, this diameter is ample, even when roof water is admitted from very large houses. Indeed, for most cases a diameter of three inches will furnish a sufficient water-way ; then, again, the smaller the pipe the more thoroughly it is flushed by the stream discharged through it.

There is, however, another considera-

tion that is important. The siphonic action, or suction, produced upon lateral branches by the discharge of water through the main shaft, is in inverse proportion to the diameter of the pipe. The sudden discharge of a water-closet using three or four gallons of water through the three-inch soil-pipe might, under favorable circumstances, produce an almost complete vacuum in the branches. The same volume flowing through a four-inch pipe would have a less effect, and through a five-inch pipe still less. Practically, where there are no fixtures higher than the fourth story, and where the admission of air from the top of the soil-pipe is very free, four inches may generally be regarded as a safe size.

CHAPTER XIV.

VENTILATING COWLS ON SOIL-PIPES.

THE upward extension of soil-pipe for complete ventilation is a matter of much importance, and one that has been considerably bedeviled by invention. Experiments instituted to demonstrate the utility of different caps or ventilating cowls have not yet been carried to a complete scientific result ; but they have sufficed to establish two important points.

One is, that every ventilating cowl of whatever kind, and of whatever effectiveness during positive winds—when no cowl is needed—is invariably an obstructor of the movement of air during calms or under light winds. It is known that

every deviation from the straight line obstructs the current by increasing the friction. Therefore, the cap or bend or cowl, one or another of which is almost always used, is of no real utility in a high wind, and is an absolute obstructor during light winds and calms.

The best result will always be obtained by running the soil-pipe straight up to a certain elevation above the roof—more or less according to the exposure—and leaving it entirely open at the top. To prevent intentional or accidental introduction of obstructing objects, it is a good practice to insert, and to secure, into the open mouth the ordinary spherical wire-basket that

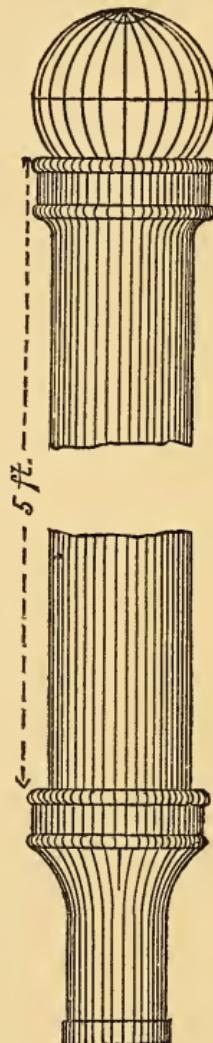


FIG. 3.—THE TOP FINISH OF A SOIL-PIPE.

is used to keep leaves from obstructing the outlets of roof gutters.

The other point is, that a universally effective increase of the movement of air is secured by increasing the diameter of the pipe at its upper end. Theoretically, the lower down the enlargement begins, and the greater it becomes at the top, the better will be the current produced. Practically, it seems to suffice to increase the diameter of the single upper length of pipe. This is most conveniently done by using an "increaser," from four inches to six inches, just under the roof, and to a set length of six-inch pipe at the top.

The owner and the architect, and all who are interested in securing good work, should bear constantly in mind the importance of making this main channel for ventilation and for drainage absolutely and permanently good from bot-

tom to top. This being assured and tested, the various fixtures or plumbing appliances may be connected with its branches.

CHAPTER XV.

TRAPS AND TRAP VENTILATION.

TRAPS, constituting one of the most essential elements of plumbing work, have for some time past occupied the careful attention of all who are interested in the improvement of house-drainage. Few who have applied their ingenuity to the subject have failed to invent and patent a "sewer-gas" trap. I took out a patent for a trap of this sort myself some years ago—probably one of the least successful of the whole list. The best of the efforts of others, thus far, have been only measurably successful. I am still using one or two of them in my own work, because they are passably good, and because

nothing else has offered that seemed better. The successful accomplishment of the object in view offers probably the most hopeful field to which sanitary inventors can now turn their attention.

Devices intended to meet existing difficulties have not all been confined to the form and construction of the trap itself. Much the most widely recommended and successfully enforced effort to meet the difficulty has been to supply what is known as the "back ventilation" of traps. Having known of the early failure of this device, before it was generally recommended to the public and taken up in the compulsory regulations of health boards, I have never been able to look upon it with favor. There is no doubt that under many circumstances it does good, but I believe that *on the whole* it does more harm.

Not only as confirming my own view,

but as an illustration of very thorough and careful experimental work, attention may properly be called to an investigation carried on for the City Board of Health of Boston, by J. Pickering Putnam, Esq., an architect of that city. These investigations have been set forth quite fully in illustrated communications to the "American Architect," which papers certainly mark a very important step forward in sanitary literature. The deductions to be drawn from these investigations are these :

While a sufficient vent-hole at the crown of a trap will prevent its contents from being withdrawn by siphonage (suction), insufficiency in such an opening, resulting from whatever cause, defeats the purpose for which it was made. Insufficiency may be due to several things. (a.) The opening may originally be made too small. (b.) It may, and very often does,

become reduced in size, or entirely closed by the accumulation of foul matter thrown into it during the use of the trap. (c.) As its efficiency is due entirely to the admission of air fast enough to supply the demand for air to fill the vacuum caused by water flowing through some portion of the pipe beyond the trap, it is not only a question of having an opening large enough to admit the air, but of having an adequate current led freely to the opening.

As the opening is into a portion of the drainage system that is unprotected by a trap, it can not, of course, communicate with the interior atmosphere of the house ; it must be connected by a pipe either with the open air outside of the house, or with the air of the upper part of the soil-pipe, above all fixtures. The ability of this pipe to transmit air in the volume required depends on its size and on its directness.

A one-inch pipe, one foot long, for example, may admit air fast enough, while a longer pipe of the same diameter, or a smaller pipe of the same length, would not do so.

One or other of the defects above indicated may very easily defeat the object, and, in so far as the opening may be decreased by the accumulation of waste matters, the object, which is fully secured while the work is new, may be permanently defeated by a condition that occurs after a little use. What seemed originally to be adequate security may become untrustworthy in time.

Then, again, the trap to which such back ventilation is applied depends for its efficiency on the permanence of its water-seal. A water-seal which has no other exposure to the air than it gets under ordinary circumstances, will not be so reduced by evaporation as to lose its value

for a considerable period ; but with back ventilation, a current of air is established through the pipe in the immediate vicinity of the trap, and evaporation becomes more rapid, destroying the seal by removing the water, in a very short time. It was an unsealing due to evaporation that first caused me to discard the method. I believe, most firmly, that when the system of back ventilation, as now practiced, is applied to all the traps of a house, the destruction of the seal, by evaporation, will be much more to be feared than it would be in the same set of traps by siphonage only, if not vented.

Traps are also frequently emptied of their water by capillary attraction. When a rag, a bit of string, a matting of hair, or any other porous substance having one end immersed in the trap, has the other end extending over the bend and leading into the discharge pipe, traps

having a seal of only the ordinary depth may be emptied in a short time by this action alone. In other cases, and even where the traps are considerably deeper, the capillary material, by increasing the evaporating surface, greatly increases the liability to evaporation in the presence of the current of air produced by the venting-pipe. While, therefore, this capillary action is not an infrequent source of the failure of a trap which is not ventilated, its effect is much more serious when the trap is ventilated.

Mr. Putnam's experiments were conducted in logical order. He first demonstrated that the air rushing through the trap to supply a vacuum caused by a flow in the piping beyond carries the water with it as a matter of course. Some of this water, striking against the walls of the trap, is thrown back to its original position, so that the whole vol-

ume of sealing-water is rarely removed with a single motion, whatever the form of the trap. However, he found that, sooner or later, under a sufficiently continued movement of air, the water, even in a deep trap, might be so withdrawn as to break the seal permanently. The time required for this depends very much upon the number of surfaces of the wall of the trap tending to throw the water back into it. It was found that, of the common traps, the ordinary "pot" or "bottle" trap offered the greatest obstacle to siphonage. It was assumed that "the severest test for siphonage to which a trap could possibly be subjected in practice would be that which would be sufficient to siphon out an eight-inch pot-trap or a ventilated S trap constructed in the usual manner."

The apparatus used was strong enough to destroy in one second the seal of a

one and one-quarter inch S trap, with a one and one-quarter inch vent-opening at the crown, having a one and one-quarter inch smooth lead pipe, sixteen feet long, connected with it ; and to siphon out an *unventilated* pot-trap eight inches in diameter, having a seal four inches deep. It was shown by this apparatus that a reduction of diameter of the vent-pipe, or an increase in its length, lessened the stability of the trap. It made a marked difference whether the pipe was straight or was bent into a coil three feet in diameter. It would seem from the description that the vent-opening was as large, and the vent-pipe described above as large, as short, and as straight, as would ordinarily be found in practice ; and it was shown that the seal was, in nearly every case, easily destroyed.

The experiments demonstrated that none of the ordinary traps can withstand

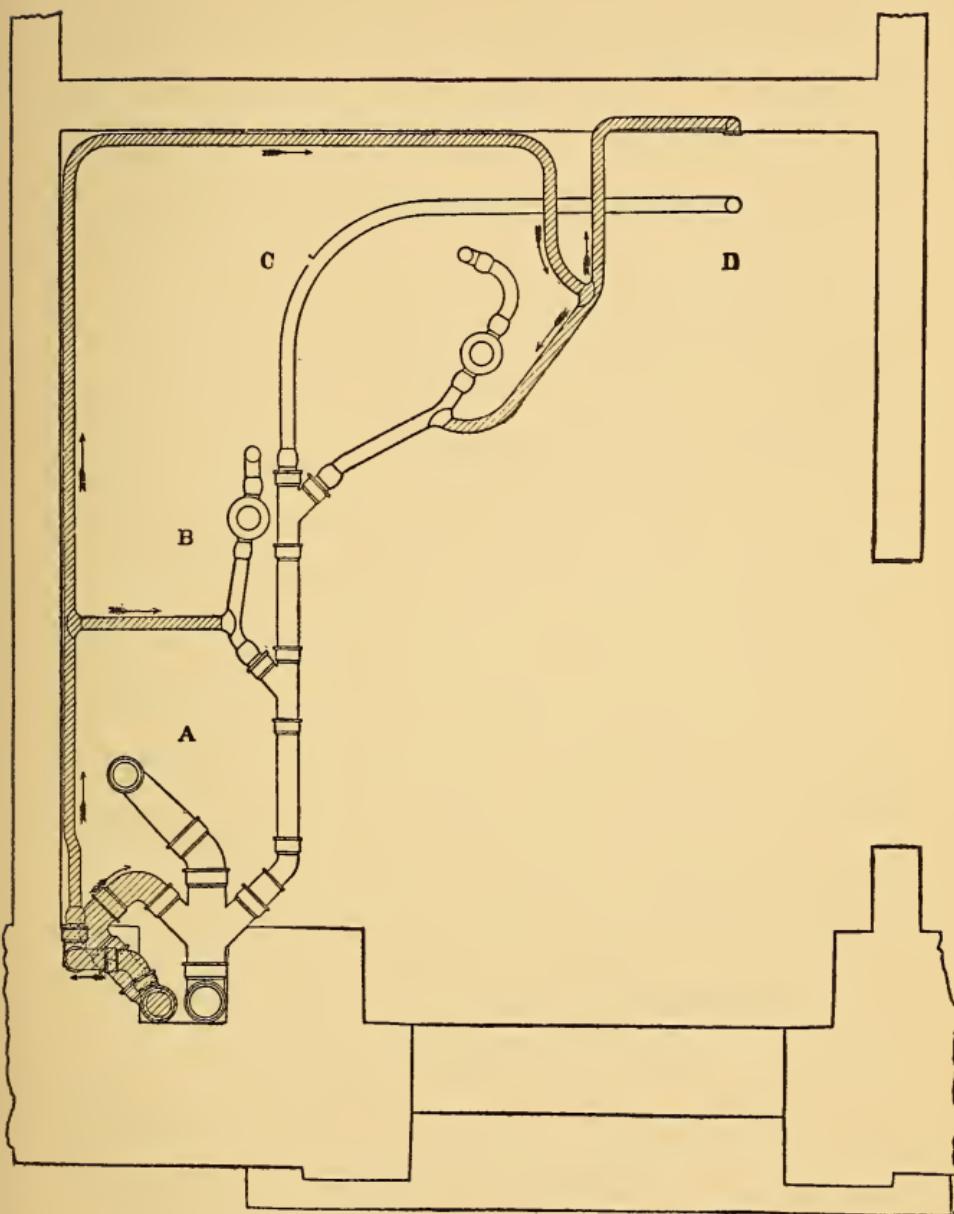


FIG. 4.—THE CROOKS AND ANGLES OF TRAP-VENT PIPES.

NOTE: The shaded pipes are the vent pipes. The arrows show the direction of the air current as moving to prevent siphonage.

a not unusual siphonic action, even with what would be considered adequate ventilation. These experiments were repeated in a great variety of ways with the same general result.

If the reader will examine the tortuous course of the various pipes shown in the accompanying illustration of actual work, or in any such illustration to be found in sanitary journals, he will see that the difference between a straight line and a coil three feet in diameter is as nothing compared with what constantly occurs in practice where the vent-pipes turn in and out and up and down, and are interrupted by frequent branches to such an extent as to increase very greatly, indeed, the difficulty of the rapid passage of air through them. I have seen a single vent-pipe, having three branches on each of two upper floors, carried down by an irregular course with sharp turns to the

traps of a bath, a sitz-bath, a bidet, a wash-stand, and a water-closet on the floor below.

Aside from this serious objection, it is not every plumber who is able to keep his head in carrying out such complicated work, and we frequently see a distinct "by-pass" leading from the drain directly into the apartment.

In tests of capillary action, the following results were obtained: Strips of hair-felt, closely resembling the matted accumulation of short hairs which forms so large a proportion of deposit in traps and pipes, were used, having one end immersed in the water of the trap and the other hanging over the bend. Other materials were similarly used. The result of the experiments, as affecting the question of ventilation, is thus set forth:

"To test the loss by capillary attraction on ventilated S traps, as compared

with the loss on the same where unventilated, an S trap having a seal of four and five-eighths inches was arranged as before with jute half filling the trap. With the trap attached to a waste-pipe, and connected with the drain in the ordinary manner, but unventilated, the loss by capillary attraction was as follows: * In the first five minutes, one-half inch; in the first forty-five minutes, one inch; in twenty-four hours, three inches; in three days, three and one-quarter inches; in four days, three and three-eighths inches. Thereafter no perceptible change took place. It made no perceptible difference whether the basin side of the trap was opened or closed, showing that evaporation in an unventilated trap is practically almost imperceptible.

* A part of this was probably due to the absorption of the water by the fibers of the jute.—G. E. W., JR.

The experiment was then repeated on the same trap ventilated at the crown into a cold flue, with the following result : In one hour, one and one-eighth inch had been removed ; in five hours, one and seven-eighths inch ; in twenty-two hours, two and a half inches ; in two days, three and one-quarter inches ; in three days, three and a half inches ; in four days, three and three-quarters inches ; in five days, four inches. Thus the loss continued at the rate of about one-quarter inch a day by evaporation, after the outer end of the jute mass had entirely dried up. This evaporation was nearly double *what it would have been had it not been assisted by the capillary attraction.* From this we see that ventilation greatly increases the danger arising from capillary attraction, often rendering the latter dangerous in cases where, without ventilation, the seal would not have been broken.

Another curious experiment was tried to determine the influence of the ventilating opening in retarding the flow through the trap by friction. The retardation was found, as a general result, to be about thirty percent. This is, of course, a reduction to that extent of the power of the stream flowing through a trap to overcome the tendency to form deposits.

It would naturally seem a strange proceeding on the part of a writer to go back to the discarded practice of former times, and to advise now what he condemned, and condemned with good reason, a few years ago. I am tempted to do something very like this. I say tempted to do it, for I am not in my own mind entirely satisfied that it is best to do it. It is best certainly to state my own present notions on the subject, leaving the reader to form his own conclusions as to the proper decision to make in the matter.

It was formerly an almost universal practice, especially in work done by plumbers not acting under professional advice, to trap the wastes of the bath and the wash-basin by connecting them with the water-closet trap below the water level. This was very urgently and very properly condemned. The water-closet trap was generally filled with a filthy mass containing more or less semi-solid fecal matter in a state of active decomposition. There was often little more flushing effect in the discharge of the closet than that produced by tipping the pan-full of sealing water on to the side of the container and letting it run slowly down into the trap. In most cases all that was removed was what had become fluid by putrefaction and maceration. The addition of warm water from a bath or basin greatly aggravated the putrefaction of such of this matter as

might remain, and of the adhering slime of the sides of the trap. The heat thus produced aggravated the pestiferous condition of the contents of the iron receiver itself. The waste-pipes of the bath and basin were fouled by the set-back of filth.

So long as traps were in that condition, the argument against such a method of trapping other vessels was absolute and unanswerable. But in decent modern work, water-closet traps in such condition no longer exist. Where two quarts of water were formerly used, we now use two or three gallons, and the larger quantity is all discharged in the time formerly required for the smaller; so that the flushing is complete and the water of the trap is always clean. This entirely reverses the conditions and answers all of the arguments originally advanced against the method under consideration.

My own attention was called to this

in a house which I recently leased for a few months' occupation. It was necessary to make some changes in the plumbing work, but it was desirable to make them inexpensive. There was a good 4-inch lead trap under the water-closet, firmly secured beneath the floor. The bath and basin were also trapped by it. To make a radical change would be costly. The opinion of the plumber coincided with my own, which was that with a hopper closet with most copious flushing—at least five times the volume of the contents of the trap being discharged through it at each use of the closet—the sealing water after use must be at least entirely safe as a seal for the other vessels. I determined to try the experiment. I watched it closely throughout the whole winter and found the arrangement entirely unobjectionable. It is true that the waste-pipes in both

cases were three or four feet long and doubtless they were somewhat coated with soap and other impurities, but there was no circulation of air through them. The slight gaseous result of decomposition was so diluted that at no time, even after the bath-room had been tightly closed all night, was there any other odor than is usually delivered into the room by the overflow pipes of the bath and basin through which there *is* a circulation of air.

Let me repeat that I do not to-day advise a return to this old method, but I believe that it is worthy of careful consideration.

CHAPTER XVI.

PUTNAM'S TRAP.

AS an incidental result of his experiments on siphonage, Mr. Putnam, by gradual stages, arrived at the invention of a trap which seems to be a practical one, and which, subjected to tests that were sufficient to break the seal of any ordinary trap even with fair back-ventilation, maintained its seal undisturbed without being ventilated. The theory followed is this: Siphonage is due to the rapid movement through the trap of air driven in by atmospheric pressure, to fill the partial vacuum formed by the withdrawal of air from the pipe beyond the trap by the inductive effect of flowing water; the first

tendency of the current thus produced is to carry the sealing-water with it.

In a perfectly smooth curved trap the removal of the water may under strong suction be complete and almost instantaneous ; in traps of irregular form, where the water in its course strikes against the wall of the trap, it is thrown back or deflected from its course ; when so thrown back a portion of the water is still carried on by the current of air, but another portion falls away from the current and resumes its position in the trap. If a sufficient number of deflecting surfaces are presented in the course of the current of air, the whole of the water, after a certain portion of the seal has been removed, is retained, and the complete unsealing of the trap can not occur.

Mr. Putnam's trap, the form of which is illustrated herewith, stands, in its normal condition, almost entirely full of water.

Under strong siphonic action about one-half of this water follows the air toward the drain ; this amount being removed, the deflecting surfaces of that portion of the apparatus thus emptied suffice to rob

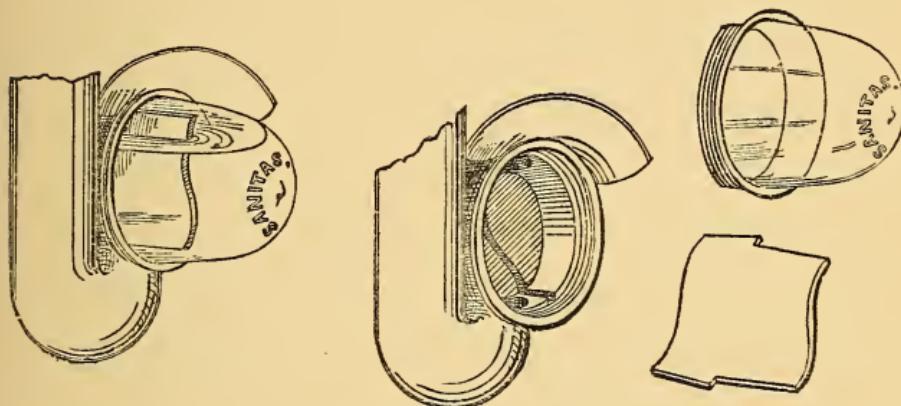


FIG. 5.—PUTNAM'S TRAP

The complete trap is shown at *a*. Its different parts are shown in the cuts *b*, *c*, and *d*. The parts *c* and *d* may easily be removed for cleansing without the aid of a plumber.

the air-current of its spray, and under no test that has yet been applied, with an open-topped soil-pipe, can the seal be broken. The interior of the trap is well exposed to view, and the arrangement for cleaning in case of need is simple. The trouble of an occasional unscrewing

of the glass cap to remove an obstruction would be a very small price to pay for the absolute security which Mr. Putnam seems to have achieved.*

This trap, or something like it, may probably come into universal use for wash-stands, baths, and laundry-tubs,—for urinals, also, where separate urinals are used. For water-closets it cannot take the place of the exposed trap of which the bowl constitutes one arm. For kitchen and pantry sinks I consider my own device better.

I have been using for some years past one form or other of mechanical trap, usually Bower's or Cudell's. They seem to be the best heretofore available, but they have never been entirely satisfactory.

* Since the above was written, I have tested Mr. Putnam's trap, finding it effective, in withstanding siphonage, and substantially self-cleansing. It seems to me the best trap that I have seen.

If the Putnam trap is not the success that I trust to its being, these perhaps will remain our best resource for a time. Whether compelled by local law to ventilate traps or not, I should not depend on ventilation, in the conviction that the simple S trap, as ordinarily constructed and as ordinarily ventilated, is totally unreliable. .

If compelled by law to construct the prescribed "back-ventilation," I should be tempted after its completion, to make the system inoperative by closing the main ventilation pipe at some point near its upper end.

CHAPTER XVII.

PLUMBING APPLIANCES.

CONCERNING patented apparatus, it is proper for me to explain the fact that in the following pages, among other things, I set forth somewhat in detail inventions of my own, which are patented, and by the sale of which I should profit. Such a course is naturally open to criticism, and such a position is always one of embarrassment. It is the usual course to describe the various appliances in common use, mentioning one's own only incidentally, and this would doubtless be thought by many persons to be the proper one for me to pursue.

It seems to me on reflection, however, the only justification for the writing of this book is to communicate to the public the best advice I have to offer.

My attention has been given for many years to details of house-drainage as a matter of business, not of philanthropy. I have had occasion to study closely, and to adopt and discard, one after another, a long series of plumbing appliances—things that have come up and gone down in the rapidly improving art which ten years ago was an extremely crude one, and in which perfection has as yet by no means been attained.

I might describe this succession of improvements, and indicate the quality, promise, and defect of each. Such information may be found, by those who desire it, very well set forth in the rather copious modern literature of the subject. The space at my disposal here would hardly

suffice for a bare cataloguing of plumbing improvements.

My own devices were in no case invented with a view to securing a valuable patent, nor for any other purpose than to improve my own professional practice. The few of these devices which have approved themselves to my later judgment, and which I am now introducing in my work, I have patented to secure an incidental commercial advantage. I shall therefore describe them without hesitation and without further comment, treating them exactly as I treat such of the inventions of others as I believe to be good. I shall trust to the good sense of the reader not to misunderstand my motive.

Special appliances for carrying out the plumber's art in the drainage of houses are to be numbered by hundreds. Invention has taken advantage of a growing

demand for the attainment of additional security against the invasion of drain-air, and has literally run wild. "Sewer-gas" has been made to do full duty as a cause of public alarm. The shops and the catalogues and the professional papers and books are full of an embarrassing variety of all manner of devices.

Many of these inventions are great improvements on their predecessors, but many are their predecessors under new names and with new complications. Few of them have been made with regard for what seems to be the most imperative need of the work—simplicity.

CHAPTER XVIII.

SIMPLICITY.

WE should especially seek the greatest possible simplicity, not only in detail but in general scheme. While the market offers a separate vessel for each possible separate use, the wisest course seems to be to reduce the number of vessels and to concentrate the various uses as much as may be. For example, I should, whenever possible, avoid the need for urinals, slop-sinks, and hoppers, by constructing the water-closet in such a manner as to supply all of these demands in a convenient and acceptable way, thus securing, incidentally, the most frequent

change of its trapping-water and the most frequent flushing of its outlet.

The urinal is almost invariably the most odorous vessel in the house. The slop-hopper is generally a receptacle for rags and rubbish, in a dark, out-of-the-way, uninspected closet; and the sink for drawing water is, in less degree, open to similar objection.

With a self-closing faucet for drawing water, there need be provided for the protection of the ceiling below only such simple means of outlet—like a safe-pipe opening through the ceiling of the basement or over a sink or a water-closet cistern—as will carry the slight drip that may come from an accidental leak. Ordinarily there is no serious objection to arranging to draw water through the bath-cock, if this is placed, *as it should be*, at the top of the tub.

Objections to this concentration of

uses, and to the abandonment of the provision of a separate vessel for each separate use, are confined mainly to trade journals, published in the interest of manufacturers and plumbers whose profits, it is thought, might be affected by the reduction. Their argument is that "cost is secondary to ample convenience."

While it is important to avoid unnecessary cost, the economical argument is the least of all the reasons for what is here proposed. The real and controlling argument is based on the great advantage of having the fewest possible points requiring inspection and care and to secure the most frequent possible use of every inlet into the drainage system. Reasonable convenience being always kept in view, three water-closets in an ordinary house are much better than half a dozen ; and the same principle holds throughout the whole range of plumbing appliances.

CHAPTER XIX.

WASH-STANDS.

STATIONARY wash-stands, where they should be used at all—in bathrooms and lavatories mainly—should, like all other fixtures of the kind, have the space under the slab fully exposed to view, so that the trap and all pipes may be seen at all times, and so that neither by accident nor by stealth may there be created the hidden untidy condition which is almost universal with the tight, unventilated inclosed spaces generally used.

The basin itself, as now constructed, has a hidden overflow which it is very difficult, if not impossible, to cleanse, and it has generally either a plug and chain to close

its outlet, or a side plug operated by a knob above the slab. Both of these are wholly objectionable. The links of the chain and the ring and attachments of the plug become fouled with soapy matters, and it is difficult to cleanse them. Practically, they are generally nasty.

To shake a filthy chain in a basin of clear water would be a very untidy preliminary to ablution. This is substantially what we do when we let water run with some force directly into a basin in which a dirty chain is hanging.

The side plug *seems* to be much nicer ; it is really less nice. There is a befouled waste-pipe leading from the outlet to the plug, in communication with a slime-coated overflow channel rising above the plug. This pipe it is practically impossible to cleanse. Its filth is constantly undergoing decomposition. Whenever the bowl is emptied it becomes filled with air ; when

the plug is closed and the bowl is filled, this air is driven in bubbles with some violence into the bowl. Not infrequently flakes of the sliming matter come with it.

The only really cleanly device that I have yet seen is what is known as "Weaver's Waste," where the plug fits closely into the outlet, forming part of the bottom of the basin, and is opened by being raised from below. It does not get over, and it may slightly aggravate, the objection to the hidden overflow; but it does enable us to wash in a clean vessel.

I am now experimenting with a small fixed basin which is simply an earthenware funnel without plug or overflow. At its top stands a movable wash-bowl to be filled from the supply-cocks in the usual manner. The bowl is emptied by pouring its contents into the funnel. That this will prove a practical success is not yet demonstrated.

Since the publication of the above in the *Century Magazine*, two or three devices to avoid the hidden overflow have come to my notice. One of them, the invention of Mr. A. W. Hoffman, of Buffalo, is an actual stand-pipe, substantially the same as the standing overflow of the bath-tub illustrated on page 155. Its peculiarity is that, instead of standing straight up in the middle of the basin, where it would be in the way, it follows the curve of the side of the basin opening at the usual position of the overflow holes—which he omits—and is quite out of the way. It is entirely removable, like the bath-tub overflow, and it constitutes the only plug at the outlet. It is worth trying.

CHAPTER XX.

WATER-CLOSETS.

WATER-CLOSETS have, naturally, been the subject of more ingenuity, and of more argument, than any thing else connected with the subject of house-drainage.

It is hardly necessary at this late date to say any thing to the limited public which reads on such subjects about the absolute inadmissibility of the almost universal pan-closet, which is still the great favorite of landlords and of builders, and which, in spite of its complication and intricacy, is still, owing to the great demand for it, sold more cheaply, and therefore more widely, than any other.

It is enough to say that those who care for safety in drainage works should neither adopt it in new construction nor retain it where it already exists. It is not, and it can not be made, a safe water-closet. To a greater or less degree, the objections to it hold in the case of every other closet in the market which has, anywhere in the course of its outlet, any thing of the nature of a valve or moving part.

It is not an overstatement of the universal conviction of skillful sanitarians to say that the range of unexceptionable water-closets is limited to such as have a free water-way from the bowl to the soil-pipe, depending for their trapping, and in some cases for their holding of a bowlful of water, on an elevation of the overflow point. These may be classed in a general way as "hopper" closets. The simplest form of this closet is a funnel-shaped vase reaching from the floor to

the seat. At the bottom it is connected with an S trap, having a depth of seal generally of from three-fourths of an inch to an inch and a half. This is a cheap and good utensil for the commoner uses. It is made of earthenware or of enameled iron, and in its best form its rear portion is nearly or quite vertical. What is known as the "short hopper," made of iron or of earthenware, has a shallow bowl, with a trap rising at its side and entirely above the floor. These are the best of the cheap closets.

Pursuing the intention already announced, to avoid any thing like a cataloguing of plumbers' supplies, and referring to what has already been said about my own inventions, I give herewith, as an illustration of the better class of closets, a vertical cross-section of the Dececo closet with its trap and discharging siphon. In this closet I have tried

to overcome the objections to the mechanical or valve closets, while retaining the very great advantages of a deep bowlful of water for the reception of deposits and for the suppression of odor.

The closet has a seal about four inches deep, a depth of water of nearly seven inches, disposed in the most useful way, and a sufficient submersion of the front part of the bowl. While it is possible under strong siphonage to reduce the depth of its water considerably, it is not possible, under any conditions that can occur in practice, to break its seal, the rising limb being sufficiently large to give an adequate passage to a continuous stream of air without removing the water to such a point as to unseal the trap. It has the further advantage that its seal is in full view and is always under control. When it *seems* to be right it *is* right.

The peculiar operation on which it

depends for its discharge is due to the use of an outlet weir below the floor, which is the invention of Mr. Rogers

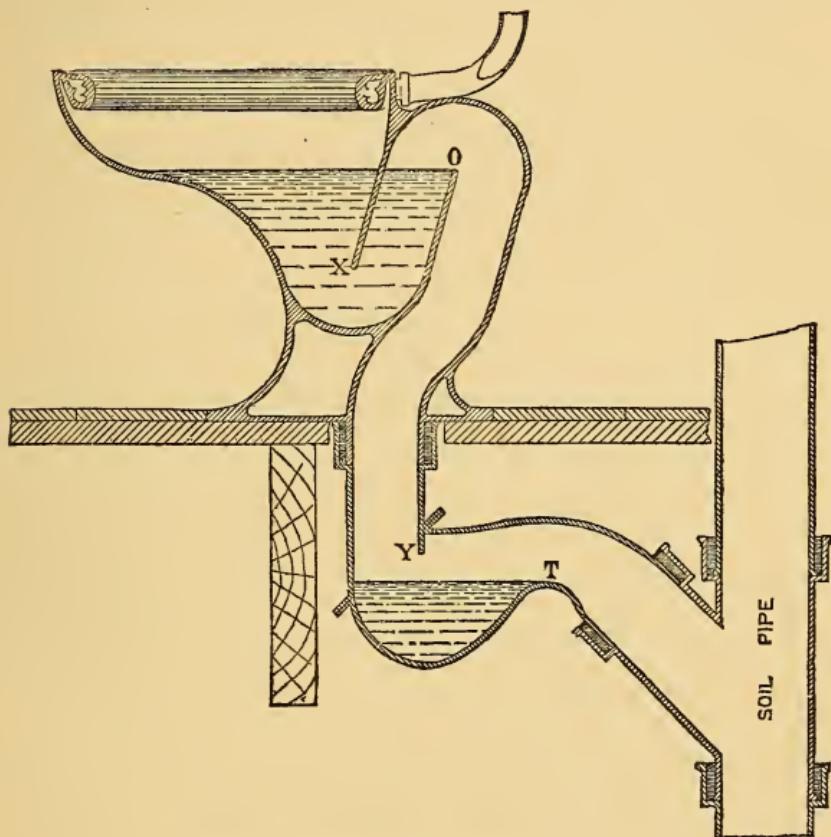


FIG. 6.—THE DECECO WATER-CLOSET.

Field, an English engineer. It is, in fact, a modified Field's flush tank.

The outer or discharging limb of the siphon reaches down into the weir-

chamber. The depth of seal is the distance from the surface of the water in the bowl to the top of the intake *X*, and this is regulated by the height of the overflow point *O*. The closet is supplied with water through an ordinary flushing-rim, connected with a service-box or cistern overhead. The cistern is operated by a pendent pull. When the pull is drawn down, a copious supply of water flows into all parts of the bowl through the flushing-rim, washing it completely and raising the level of its water rapidly. The surplus overflows at *O* faster than it can be discharged over the weir-top *T*, without rising so high as to close the opening at *Y*. This closure shuts off the air in the siphon from the air in the soil-pipe, with which it is ordinarily in communication. The water flowing through the long limb of the siphon, in an irregular stream, carries the air with it, and

there is soon established a strong siphon action, which continues until the water in the bowl, into which a strong stream continues to flow, descends below the top of the intake *X*. Then air is admitted at this point, and the flow through the siphon is checked. The discharge at *T* continuing, the water in the weir-chamber soon falls sufficiently to allow air to enter at *Y* and empty the siphon. The water in that part of the siphon between *X* and *O* falls back and establishes an immediate hydraulic seal at the intake. The service-box is so arranged that after the main supply is stopped a small stream continues to be discharged into the bowl until it is filled to the height of the overflow point.

It was evident from long and successful experience with Field's flush-tank, that the principle on which this closet is constructed is a perfectly correct one.

It has undergone few changes since its original construction three years ago, and the several hundred closets now in use are invariably satisfactory, so far as reported.

The first ones made, five in number, were set up in the White House after the removal of the President in 1881. They are still perfectly successful in their working. After ample trial for servants' use, and for more than a year in a girls' boarding-school, an experimental one is now being tested with the rough use and rough handling of the operatives of a spinning-mill. It has, during the seven weeks since it was put in, given complete satisfaction. So far as I can see, this closet accomplishes perfectly every purpose for which a water-closet, slop-hopper, or urinal is required.

In practice, it uses at each operation over two and a half gallons of

water, which gives a thorough flushing to the soil-pipe and drain, while it has the great advantage of sending a good part of its water into the soil-pipe in advance of the foul matter, lubricating their passage through the whole drainage system. Although this considerable volume of water is essential to its complete efficiency, the closet may be emptied by pouring into it suddenly less than two quarts of water. A large pail of slops thrown in as rapidly as possible fails to overflow it, and barrels of water might be poured through it in succession as fast as the three-inch outlet can discharge it.

The setting of water-closets in the best manner is most easily secured when hopper or other plain closets are used ; that is, closets with no machinery under the seat. By the best manner, I mean such setting as requires the minimum of carpentry, preferably nothing whatever but

a single well-finished hard-wood plank with a hole through it, resting on cleats at the sides and hinged to be turned back out of the way. It is better that there should not even be a cover to the hole. The entire closet, inside and out, should be as thoroughly exposed to view, to ventilation, and to perfect cleansing as possible.

If the floor and back and side walls be covered with glazed tiles—preferably white—so much the better; but a cheap and satisfactory setting is secured by a slate flooring with hard-wood finish around the sides. Even oil-cloth on the floor, and the ordinary base-board and plaster at the sides and back, answer a very good purpose; the great thing is to have a perfect exposure to sight and to air.

The costly housing-in of the closet by a close seat and cover and a close riser in

front may serve a very good purpose as an ornamental piece of cabinet-work, but it too often covers a condition of things that no fastidious housekeeper would knowingly tolerate. Sloppage, leakage, and the tainted air rising through the irregular holes left for the soil-pipe, unite to make this space untidy and in every way objectionable. Some sort of housing-in is necessary with closets which have machinery about them, but the whole class of hopper closets may be entirely free from any thing or any condition to make such concealment desirable.

I would by no means imply that there are not a number of other very good closets in the market besides those here described. I have had in use in my own house, for five years, a closet which holds a reasonable depth of water in the bowl, which has a high overflow

point, and of which the contents are driven out by a strong jet of water shooting up the outlet pipe and over the overflow. With careful attention, largely made necessary by the improper shape of the bowl, this closet is so satisfactory that I have not thought it worth while to take it out and substitute the Dececo. There are other closets holding water to a considerable depth by the same method of elevating the overflow point and discharged by one means or another which are quite acceptable.

It is possible that my decided preference for the Dececo is only an incident of paternity—but it is a decided preference nevertheless.

CHAPTER XXI.

SINKS.

KITCHEN and pantry sinks are used for the discharge of matters which in their original condition are not offensive. They are, therefore, in the popular estimation, of much less serious consequence to the sanitary condition of the house than are water-closets. This temporarily different condition, however, of the matters which they receive, very soon gives place to a similar condition of the matters which they have discharged.

After a little retention, putrefaction sets in, and the refuse food of the sink becomes as offensive and objectionable as does the digested food of the water-closet.

In the one case as in the other, it is very important to secure a complete removal of all foul matters well beyond the house before putrefaction. The liability to detention and deposit is much greater in case of the sink than in the case of the closet, for the reason that, with much less flushing, there is discharged through its waste-pipe a considerable amount of heated and temporarily liquefied grease.

This grease passes the strainer of the sink and is unnoticed, but, as it cools along its course, it attaches itself to the sides of the pipe in constantly increasing accumulations, until the channel is often nearly or quite obstructed. It is by no means pure grease that is thus attached. In its congelation there are involved particles of highly putrescible matters, and the ordinary kitchen-sink waste-pipe is the seat of a constant decomposition—mostly beyond the trap, and for this reason not

especially noticeable—but especially foul nevertheless.

Not to get rid of the putrefaction, but to prevent the obstruction of the pipe, there have been invented various forms of grease-trap, having for their purpose the hardening of the grease under conditions which will allow it to be removed. These grease-traps would answer a better purpose than they do if we could depend on their being regularly attended to; but so long as water will flow from the sink, servants will give themselves but little trouble about such accumulations. No accumulation for longer than a single day should be tolerated.

I have employed a device that has now been in considerable use for several years, which seems to meet the requirements of the case quite completely. There is built beneath the sink, and in connection with it, a “flush-pot” large enough to hold

several gallons of water. Its top is cov-

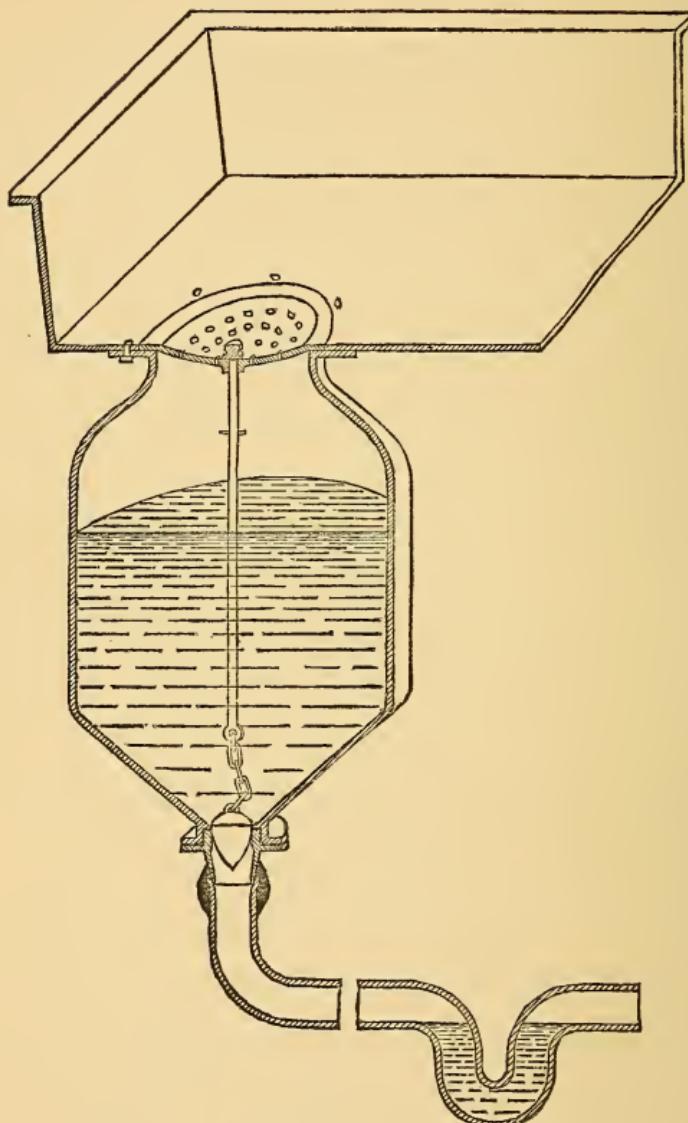


FIG. 7.—THE DECECO FLUSH-POT FOR SINKS.

ered by a strainer, about eight inches in

diameter, and pierced with large holes. This constitutes a portion of the floor of the sink. The outlet of the flush-pot is closed with a plug, like a wash-basin plug, which is attached to a spindle rising through the strainer. The outlet is connected with the drain by a small pipe, having a common trap, which is useful only during the short periods when the plug is withdrawn.

Ordinarily, the outlet stands closed. Water thrown into the sink flows through the strainer, leaving all coarser substances to be brushed up and *burned in the range*.* Little by little, the flush-pot becomes filled, and during this slow process most of the grease becomes congealed. When it is nearly full, the water can be seen, even before it reaches the strainer. Then

*This simple cremation of the worst elements of house-garbage costs no money and little trouble. It solves one of the difficult domestic problems.

the spindle and plug are raised and held up until the gurgling of air through the trap indicates that the pot is empty. Then the outlet is closed and the filling begins again. The strainer and spindle may be lifted out together, exposing the whole interior of the flush-pot, which may thus be given a daily cleansing and kept in as good order as any other iron vessel in the kitchen.

The theory of the success of this apparatus is very simple. There is absolutely nothing running through the waste-pipe except during the moment when the flush-pot is being discharged, and then the whole mass flows with such force as to carry every thing with it.

At my own house, having occasion to inspect the main drain (diameter three inches), I found that neither a copiously supplied water-closet nor a bath-tub had such flushing effect as had the discharge

of the flush-pot in the kitchen. Its flow filled the drain more than half full with a stream of good velocity.

In the first application of the flush-pot to pantry sinks, it was given about the same capacity with that of the kitchen sink. As, however, it is desirable to fill the pantry sink for washing dishes, it became necessary to waste the large volume needed to fill the flush-pot. To avoid this its capacity has now been reduced to about one gallon, which is enough to insure a good flow from the ordinary accumulated drippings of the sink. When the sink itself is filled, its contents as well as those of the flush-pot constitute an abundant flushing volume, the strainer being sufficiently open to allow a rapid flow.

CHAPTER XXII.

OVERFLOWS AND STOP-COCKS.

OVERFLOWS, intended for the safe removal of surplus water from bathtubs, wash-bowls, etc., are necessarily on the house side of the trap. They are practically never reached by a strong flushing stream, and their walls accumulate filth and slime to a degree that would hardly be believed. They constitute the nastiest element of modern house-drainage of the better order. Perhaps they are not a serious source of *danger*, but they are, more often than any other part of the plumbing work, except the urinal, the source of the offensive drain-smell so

often observed on first coming into a house from the fresh air.

In the stationary wash-basin as at present arranged, there seems to be no easy way to get over the difficulty, a difficulty which of itself should be a sufficient reason for excluding these fixtures from sleeping-rooms. The basin overflow is objectionable for substantially the same reason that the bath-tub overflow is objectionable, though perhaps to a slighter degree owing to the smaller surface exposed to the accumulation of deposits.

The concealed overflow of the bath-tub may, fortunately, be dispensed with, and in this case the difficulty inseparable from the arrangement may be obviated. It will, perhaps, be instructive to illustrate by a diagram the reason why the usual hidden overflow is so objectionable.

In this cut, *A* is the waste-pipe at the bottom of the tub, by which its contents

are discharged on the withdrawal of the plug. *B* is the overflow pipe, its connection with the tub being through a perforated screen. *C* is the trap by which

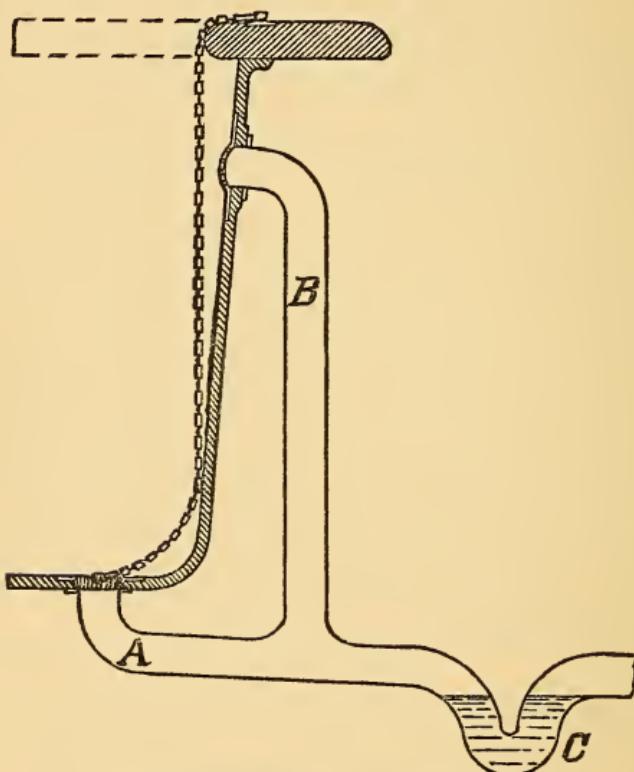


FIG. 8.—HIDDEN OVERFLOW OF BATH.

the waste-pipe is shut off from the drainage system, and which has incidentally the effect of retarding the flow of water through the waste-pipe. If we suppose

the tub to be filled to the level of the overflow and its waste-plug to be removed, the water will immediately rise in the overflow pipe to very nearly its height in the tub. It is of course impregnated with the impurities of the water in the bath. Furthermore, the lighter particles of organic matter flowing through the waste will, some of them, rise by their levity into the overflow pipe. The water rushes up into this pipe with much force, but it descends only very slowly as the level in the bath descends, so that at each operation there is a tendency to deposit adhesive matters to its walls. What is so deposited decomposes and escapes little by little in a gaseous form through the perforated screen into the air of the room. There is a free circulation of air through the pipe when the plug is out. The amount of these decomposing matters is somewhat increased, though prob-

ably not very much, by floating particles passing through the screen when the overflow is performing its legitimate function.

This is the simplest statement of the proposition, and this is perhaps the least objectionable form of hidden overflow. Where the waste-pipe is closed at the bottom of the overflow by a plug or valve attached to a spindle rising through the overflow-pipe—a very favorite device with some plumbers, and already described in connection with wash-bowls—the difficulty is in every way aggravated and the amount of fouled surface is much increased. The inherent defect here illustrated attaches to every overflow of this general character connected with any part of the plumbing work.

In the case of a bath-tub it may very easily be avoided, as shown in the next diagram, by doing away entirely with the

overflow-pipe *B* and its perforated screen, and using for the closure of the waste-outlet *A*, as a substitute for the ordinary plug, a pipe fitting into the outlet and

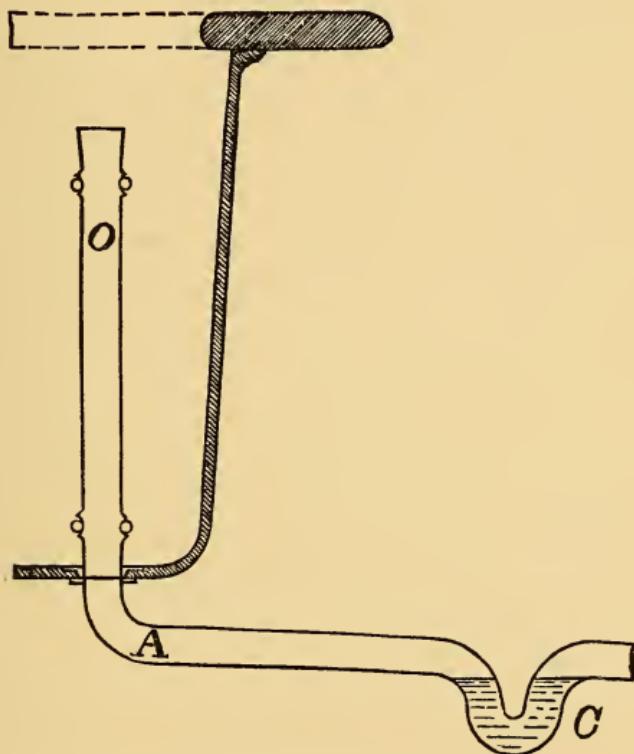


FIG. 9.—STANDING OVERFLOW AND PLUG FOR BATH.

rising to the height desired for the water in the bath. If the upper end of this pipe be given a trumpet-shaped opening, its capacity will be increased. Unless

Hoffman's overflow prove successful, such a substitute for the ordinary overflow is not applicable to wash-bowls as now made. It may be made available for pantry sinks if the pipe can be so placed in a corner as not to interfere with the proper use of the vessel. If its universal adoption for bath-tubs could be secured, a very wide-spread source of mild nuisance would be done away with. Fortunately, it is far cheaper than any arrangement for which it is a substitute. It is one of its incidental uses that it enables us to get rid of the dirty chain attached to the ordinary bath-plug. Weaver's waste, which is one of the best devices for closing the outlet of an ordinary wash-basin, is also arranged for the bath. In neither case does it in any respect modify the objection to a foul overflow.

Stop-cocks need no special notice in this paper, except in connection with

bath-tubs. Most, if not all, of the English earthenware bath-tubs imported into this country, and many even of the planished, copper, and enameled iron tubs made here, are furnished with an ingenious device for delivering the supply near the bottom of the tub in such a manner as to mix the hot and cold water at the delivery and to admit the supply with little noise. The last may be an advantage. The first may be perfectly accomplished by delivering the hot and cold water through a single nozzle at the top of the tub in a convenient position for drawing water for other uses.

There are doubtless many cases where the bottom delivery of the supply may be free from sanitary objections, but they are fewer than would be supposed, and it seems strange that the frequent serious objection to the arrangement should have been so generally overlooked. This bot-

tom delivery is substantially a cock for drawing water, and all who use such cocks for filling wash-bowls must have noticed a frequent indraft of air when the cock is open. Water being drawn from the lower part of the supply-pipe, the head in the upper part is annihilated, and if a cock is opened the water falls in the supply-pipe, air rushing in to take its place.

The indraft of *air* is not of much consequence, but the indraft of a pipeful of *dirty water* from a bath-tub does not suggest a pleasant modification of the quality of the water-supply of the house. In this case, as in many others, an apparent mechanical improvement, securing only incidental benefits, should be discouraged. In my judgment the only perfectly safe and satisfactory arrangement for baths thus far devised is one by which the water is drawn through a faucet above the water-line, and by which the outlet is

closed by a stand-pipe serving as the *only* overflow of the tub.

Laundry trays, as they are now almost universally arranged, are hardly to be regarded as a conspicuous element of the sanitary works of a house. There are few cases in which we find any thing about them that is seriously objectionable. With them, as with sinks, water-closets, and wash-basins, it is best to avoid all unnecessary carpentry. It is, of course, best that they should be made of some other material than wood—either slate, soapstone, cement, or earthenware. Earthenware tubs, supported on galvanized iron legs and surrounded by a simple border of hard wood, seem to ask for no improvement.

CHAPTER XXIII.

AN EXAMPLE OF SIMPLE AND GOOD WORK.

SIMPLICITY in house-drainage, and a marked contrast to the multiplication and complication so often found in the better class of buildings, are illustrated in the case of a very fine and costly house, the plumbing of which I am now superintending.

It has in the basement one kitchen-sink with the flush-pot, and four laundry-tubs. The main soil-pipe runs under the basement floor near both of these; it is of extra-heavy iron, with the joints leaded and tested, under water pressure, to absolute tightness. It is then, so far as it lies below the floor, completely

encased in Portland cement mortar, and this, again, in well made concrete; it turns up near the laundry-tubs, and near the ceiling it receives a branch pipe coming from a lavatory on the floor, twenty-five feet away; it then passes through the floor and receives the waste of the flush-pot of the pantry-sink; rising to the ceiling, it receives the waste of a bath-tub and wash-stand on one side, and on the other the waste of a Dececo water-closet and wash-stand; passing through the next floor, it receives the wastes of the fixtures in the servants' bath-room—a straight hopper closet, a bath-tub, and a wash-stand; above the ceiling of that room, its four inches size is increased to six inches, and it passes with this larger diameter a short distance through the roof, its top being closed by a large wire basket inserted in the hub of the six-inch pipe; the branch pipe under the ceiling

of the cellar is connected with a Dececo closet and a wash-stand in the lavatory, and is continued up, without other connections, to its increaser and a six-inch top joint through the roof.

This is the full complement of the drainage appliances which, in accordance with modern ideas, it was thought necessary and wise to introduce into a house which, even five years ago would have had twice as many closets and baths, and at least four times as many wash-basins, to say nothing of two or three urinals and one or two house-maid's sinks. The whole cost of the work to be done, including all hot and cold water-supply, and the outside connection with the sewer of six roof-water conductors, is just about one thousand dollars. Under the old method, supposing the same material and workmanship to be used, and considering the long lateral waste-

pipes and hot and cold water and circulation pipes of the different baths and basins, the cost would hardly have been less than twenty-five hundred dollars. The saving of cost effected is, in my judgment, of much less consequence than the simplicity secured.

CHAPTER XXIV.

OWNERS, ARCHITECTS AND PLUMBERS.

IT has already been said that the character and arrangement of the plumbing work of modern houses are much more controlled by plumbers than by any body else. This is generally quite as true with reference to houses built under the advice and direction of architects as in other cases.

There are a few architects who take a lively interest in sanitary works, but they are very few. The fact is, that an architect is, generally, either disqualified or disinclined, by nature or by training, for the minute attention to hidden details which the proper control of house drain-

age would require of him. It is not to be expected that a man who has made himself a safe guide and leader of public taste, who has acquired a mastery of the engineering problems involved in safe and economical construction, and who has learned how to contract a client's desires to the requirements of space and of price, should have been able to keep himself *au courant* with the rapidly growing improvements of an art, which, twenty years ago, was only a trade.

As a matter of fact, the architect rarely knows or cares any thing about the plumbing of a house beyond the selection of the spaces to be given to its fixtures. He gives the plumber a rough idea as to where certain fixtures are to be placed, and as to their general style. Beyond that—I am not speaking of all architects, but of architects as a class—he is generally indifferent to the whole business.

The result is—as it may be. Some plumbers are capable of writing good specifications and some are not. It by no means always happens that the best plumbers and the best architects work in conjunction.

I write more feelingly on this subject, because I have recently, in more than one instance, on being called to take charge of the drainage of very fine houses already in course of construction, had the plumbing specifications submitted to me. They happen in all cases to have been written for places where the Board of Health has established no formula for the work and has furnished no printed blanks. Not one of them would have done fair credit to an intelligent plumber of the year of our Lord, 1870. In every case an unnecessary amount of work would have been done and much of it would have been unsafe when it was done. The

question often comes up, in the practice of an engineer of sanitary drainage, as to whether or not to change such work as these specifications provided for, it being already constructed and in operation. No one who knew the first rudiments of the business, would think of introducing it into a new building.

In one case, I was called to a house so near completion that all of its main pipes had been put in place, and a wilderness of pipes they were. I recommended that they be removed, all but one of them, and that a fresh start be taken. The owner referred the question, as owners so often will, to the arbitration of dollars and cents. An estimate, made by the plumber who had done the work, showed that it would be somewhat cheaper to wipe it all out, begin again, and follow my plans, than to finish what he had begun, according to his own.

The criticism here is in no sense against the plumber nor against the architect, but against the *system*. If an architect tells his client that he prefers to have an expert to take charge of the plumbing, the client may object to paying an extra fee or, as it seems to him, two fees for the same work. The architect, of course, can not be expected to pay for the extra services, so he follows the old course of turning the matter over to his plumber, and, very properly, justifies himself with the sufficient plea of Usage. As an incidental result, the owner generally pays considerably more for the tolerable work that he gets than he would pay, fees included, for the more perfect work that he might get.

Another point in this connection is of great interest. It is being actively discussed by the better plumbers and by the sanitary journals. It is that plumbing

work should, at least, never be done at second hand. That is, that the whole job should not be given to a contractor, allowing him, in his turn, to contract out the plumbing work. Indeed, this results so generally in positive injury to the health of the people that it would seem a proper subject for legislative prohibition.

Naturally, all that the building contractor is responsible for is, that water shall flow and waste shall run, without bursting the pipes or destroying the ceilings, until after the house has been accepted and taken off his hands. His only connection with the enterprise is a business connection and his only motive is his business interest. He builds the house to make money on it, and the more cheaply he can get the architect's requirements for water-closets, baths, tubs, sinks, etc., complied with, the more money he will make.

While this course of sub-letting is bad enough in the case of houses built for immediate sale, or in the case of tenement houses, it is in a certain way explicable ; but that any man who is building a house for his own occupation, should permit this vital element of its safety as a habitation, to become the object of dicker and flint-skinning between two men who care only to make what money they can out of it, is most incomprehensible.

If it is suspected that what is here written is written with a view to the pecuniary interest of my own profession, with its rapidly growing membership, I confess at once and most frankly that the suspicion is well founded. I should not have taken the trouble to write this book for the questionable compensation it offers in the way of copyright. I have written it because I think it may advance the interests of engineers. If that should be

thought an improper or a selfish motive, let me say that I trust it will also, and in much greater degree, advance the interests of all who live in houses which have or which need drainage works of any kind. That it will also benefit the better class of plumbers, ought not to be doubtful.

CHAPTER XXV.

SEWAGE DISPOSAL FOR ISOLATED HOUSES.

THOSE who live in isolated houses, in the country and in the smaller towns, generally solve the whole problem of sewage disposal by the simple formula, "Out of sight, out of mind." The universal remedy is a hole in the ground into which every thing in the shape of liquid wastes is delivered. The only criticism that most people apply to the apparatus relates to the frequency with which it requires to be emptied and to the cost of the operation.

What goes on in the cesspool, and in the ground about it, is entirely unheeded. So long as the overflow is disposed of,

the devil may care what the hidden processes of disposal are. Unfortunately, the devil does care, and much of the worst work that he effects, in his assault on the health of his unwitting subjects, has its starting point in the common cesspool. The worst sewer in the world is rarely so bad as the usual cesspool. In comparison with it, a sewer that would be regarded as very foul is purity itself.

The cesspool works its injury chiefly in three directions:

A. It holds an accumulation of filth of the worst character, in a state of active putrefaction, giving off gases produced by a decomposition that takes place under conditions of the worst sort. These gases can not be entirely suppressed while a channel remains open for the admission of liquid to the cavern. Unless delivered into the atmosphere, which they inevitably taint, they find

their way back more or less directly into the drainage system of the house.

B. In so far as the walls of the cess-pools and the surrounding earth are permeable to their passage these gases pollute and poison the ground air, and if near the house, this finds its way from the earth into the cellar.

C. Its liquid leachings and ooze, enriched with the soluble productions of a fatal putrefaction, travel through porous soils, through gravel or sand streaks in heavy ground, and through fissures in rocks to pollute the water of wells and springs even at a considerable distance.

If the fraternity of sanitarians throughout the world are in accord on any one point, it is that the common cesspool, even under the best conditions, is absolutely inadmissible. Surely no householder having the least regard for the health of his own family, or for that of

his neighbors, once realizing the inevitable condition, will tolerate its perpetuation. Fortunately it is no longer necessary that, even in connection with the simplest and poorest house, this dangerous nuisance should longer exist. The sanitary fraternity are also in full accord as to the general principles of an improved mode of disposal.

What concerns us, in this connection, is a proper means for the disposal of the organic refuse and filth contained in the liquid wastes—including those of the water-closet and kitchen sink—of isolated houses which have at least a small area of land connected with them.

The principle on which the best disposal thus far devised is based is this:

The aerated upper layers of the soil are a universal destroyer of whatever organic impurities may be deposited on the surface or intermixed with the earth. Dead

organic matter is completely destroyed by natural processes of oxidation and nitrification, wherever, under natural conditions, it is exposed directly or indirectly to the action of the atmosphere in the soil. There is little doubt that the agents of destruction in this case are the bacteria of putrefaction, those all-pervading micro-organisms, whose increase, growth, and life involve the combination of atmospheric oxygen with the elements of organized matter, a combination always set up under conditions favorable to the growth of these bacteria. Aeration is a necessary condition of the process.

When urine or other foul liquid is thrown on to the surface of the ground, it sinks into it and deposits on the surfaces of its particles the organic impurities which it contains. Its water, descending still further, has become essentially purified. As the water sinks away, air enters

to take its place, and every particle of soil that is coated with the waste matters is surrounded with air rich in oxygen. The bacteria, present in all fertile soils, combine the two—much as the respiratory process of higher organisms combines the oxygen inhaled by the lungs with effete matters of venous blood.

This is a slight and popular statement of the results of recent scientific investigation. The process is a continuous one. The destruction of one dose of wastes being accomplished the destroyers are ever eager for more. For their successful and continued operation it is only necessary that the waste matters should be supplied and that air should be furnished alternately. This is the principle on which is based the success of the system of sewage purification by broad irrigation and by intermittent downward filtration. It is as effective in taking care

of the waste of a city as of that of a single house, the difference being only a difference of degree.

In the case under consideration, the disposal of the wastes of a single dwelling, generally on land very near the house, must necessarily be accomplished in a hidden and inodorous manner. The sanitary result would probably be complete if they were delivered intermittently over the surface of a lawn. Other considerations make it important that sewage be kept out of sight and that the distribution of the wastes be beneath the surface.

The Rev. Henry Moule, the inventor of the Earth-Closet, seeking means for disposing of liquid wastes of the household, for which the closet is not suited, laid agricultural drain tiles along the foot of a grape-vine trellis, leaving their joints open, so that the slops reaching the

drain could escape freely into the ground. The influence of this subsoil irrigation on the growth of the vines and of grass was very marked and the disposal was complete and continuous. This was about 1868. Later, Mr. Rogers Field adopted a modification of the same device in disposing of the liquid wastes of cottages at Leatherhead, England. He added the important improvement of a flush-tank in which the liquids were retained until it became full, the whole volume being then rapidly discharged into the tiles.

This was a great advance. It secured the uniform distribution of the liquid throughout the whole length of the drains and gave ample time, while the tank was refilling, for the water to settle completely away, allowing air to enter and complete the destruction of the impurities before the next discharge.

The writer, in connection with his residence at Newport, adopted Mr. Moule's device as soon as it was made known, and added Mr. Field's improvement soon after the publication of his process. At first, a little difficulty resulted from the delivery of grease and flocculent matter, into the tiles, leading to the obstruction of their joints. Early in the experiment, it usually became necessary as often as once a year to lift the tiles and wash out their accumulations. This led to the interposition of a settling basin to retain all of these coarser matters. Later the settling basin was placed on the house side of the flush-tank to prevent the disturbance of the deposits in the former by the vigorous discharge of the latter.

The house was provided with earth closets, but every thing not deposited in these was delivered to the drains, which were laid under a lawn adjoining the best

rooms of the house and a piazza that was much used. The net work of drains began not more than fifteen feet from the edge of the piazza and the furthest corner of the section was not more than fifty feet away. The system worked most satisfactorily for eleven years, when the construction of a sewer in the adjoining street made it no longer necessary to use it.

During the whole period of the experiment, the condition of the tiles and of the soil immediately adjoining them was frequently examined. If the opening were made immediately after the discharge of the tank, the earth near the drains had a decided odor, but all other times, even close to the open joints from which the discharge had been copious, there was absolutely nothing to suggest impurity. A handful of earth which a few hours before had been saturated with the foul

liquid had no other appearance or odor than that taken at the same depth from a part of the lawn entirely beyond the influence of the system.

This method of disposing of waste liquids has been used by many engineers and on hundreds of places in different parts of the country. So far as known, wherever the details of the system have been properly regulated, the result has been entirely satisfactory.

In 1876, in connection with the sewerage of Lenox, Mass., there being no other available means of outlet, a large flush-tank was built at the upper corner of a field near the village, and 10,000 feet of absorption drains were laid. From that time to this, the operation of the system has been completely successful. It has not been used in winter, but it has since been demonstrated that there is no reason why it might not be.

At the Hotel at Bryn Mawr, Pa., a system even larger than that at Lenox has been in successful use since 1881. Here, the sewage had formerly been delivered into a brook which ran through private property. The change was made to avoid legal proceedings threatened by the adjoining owner. A little difficulty occurred at first from an unequal distribution of the flow and because of the steep grade necessarily given to some of the drains. These defects were remedied and the working of the whole system is now completely successful.

At the Woman's Prison at Sherburn, Mass., where about 30,000 gallons of sewerage is delivered per day, the conditions are extremely difficult. Only a small area of land at considerable elevation could be reached, and this was of a very unfavorable character. The system here has been on the whole successful

though, owing, as is believed, to sluggish drainage through the heavy subsoil, the amount of drain tile used, 20,000 feet, has at times proved inadequate to the work. The difficulty has not yet been completely solved, nor is it certain that even more thorough drainage will enable the small area available to cope with the very large volume delivered. It is not unlikely that under the circumstances the only possible solution will be to improve the drainage of the ground as much as possible and to restrict the amount of water used in the establishment as much as is consistent with a proper working of the closets, laundry-tubs, etc.

However, the difficulties which have arisen in this place have but an indirect bearing upon the problem now in hand. There are few individual houses, so far separated from each other that their best relief may not come by public sewerage,

which have not sufficient ground about them for the successful application of this system.

So far as the disposal of slop-water is concerned, in the case of houses of the smaller class, where expenditure in construction must be reduced as much as possible, I can not do better than to repeat here directions given in a paper prepared for the West Ewing Improvement Association and published by them in 1880 :

THE DISPOSAL OF KITCHEN SINK WASTE,

Chamber slops and laundry water, is a question which has engaged the study and ingenuity of the world for many years. I believe that, so far as isolated country-houses are concerned, it has been perfectly accomplished by the system known as “sub-surface irrigation.” This system is susceptible of much elaboration, and may be carried out in an expensive manner ; but its essential results may be secured with an expense so trifling that not even in the smallest tenement-house need its cost be an obstacle

to its adoption. It is based on the fact that the surface soil which is within the reach of the roots of grass or other plants, and of the action of the atmosphere, is a very active destroyer of organic matter. A cotton rag buried a few inches under the surface is very soon entirely consumed by this action ; and all decomposable matter so placed is destroyed by oxidation or slow combustion as completely, though less rapidly, as when it is thrown into the fire. In order to make this process continuous, it is necessary that there should be free access of air into the pores of the soil. In the case of liquid wastes, it is necessary that the discharge be intermittent, for when a constant small stream runs into the ground, saturating a small area, the entrance of the air is prevented and the oxidizing action is retarded. With even a few hours' interval between the two discharges, the water settles away into the ground, which acts as a filter, holding back all of its impurities, and its descent is followed by the entrance of fresh air, which immediately attacks and destroys the retained organic matter. If the liquid is thrown on the top of the ground, it produces in a short time a puddled condition of the surface which prevents the free entrance of air. It is, therefore, desirable to introduce it into the soil

below the surface, allowing it to soak away in so gradual a manner that no puddling of the earth can take place. This introduction into the earth is by the use of common agricultural drain tiles with open joints, laid not more than ten inches below the surface. The intermittent action is secured by delivering liquid wastes into these tiles, not constantly, but from time to time.

In the case of a small tenement-house, where only two or three pailfuls of waste liquid are produced in the course of the day, this absorption drain need not be more than forty feet long. It may be one continuous line of pipe, or it may be several shorter pipes branching from one main line, according to the space devoted to the use. It may lie under the grass near a row of currant bushes, under a grape-vine trellis, under a grass-plat, or elsewhere. Opening into it, there should be a box large enough to hold a pailful of water ; and the joints of this box, as well as the space around the pipe leading from it, should be made tight. It may be covered in winter as a protection against frost ; but in summer it will be better that it should have a full exposure to the air. A wire cloth or other screen should be provided at its top to act as a strainer to hold back coarse matters which might obstruct the

pipe. From time to time this strainer, which should be movable, can be emptied into the swill-barrel, or its contents may be thrown upon the manure heap, or buried in the ground. The liquid which passes the strainer will enter the pipe, leach out into the ground and be purified. The arrangement described will be quite sufficient to receive the contents of one or two wash tubs ; but it should not be connected with the kitchen sink delivering only a small flow. Whatever is thrown into it should go with a rush, so as to reach as far as possible through the whole length of the drains.

For houses of larger size, producing a greater amount of waste, the length of drain should be from one hundred and fifty to three hundred feet, including all branches, according to the size of the family and the freedom with which water is used. A uniform distribution through this length of pipe can not be secured by throwing into it a pailful at a time. Some arrangement should be adopted which will retain water to the amount of a barrelful or more, and which will, when the tank becomes full, deliver the whole contents suddenly. The apparatus best adapted for this use is known as "Field's Flush Tank." A much cheaper arrangement can be made at home, which, while not having the advan-

tage of the Field automatic siphon, will secure the same result, if attention is given to opening and closing its outlet by hand. The construction of this tank is very simple. It is made of plank, and is divided into two compartments by a grease-catcher, which will prevent congealed grease, floating substances and heavy matters from passing into the discharging chamber. It also has a spatter-board, to prevent the disturbance of the sediment, and a screen to hold back coarse matters. It is, in fact, a flushing tank with a grease-trap intervening between it and the source of supply. This interposition of a grease-trap is covered by a patent of my own ; but permission is hereby given to any member of the West Ewing Improvement Association to use it, without charge. The size of tank indicated in the sketch is sufficient for three hundred feet of drain. The capacity of its second or discharging chamber may be proportionately reduced or increased as the length of drain is made greater or less. The grease-trap may be attached to any waste-pipe from the house, or it may be filled by pouring into it the contents of chamber pails, wash tubs, slop pails, etc. The grease-trap serves to hold back all obstructing matters. The outlet of the discharging chamber is closed by a plug of wood, or by an india-rubber

ball; the stopper being attached to a chain, by which it may be lifted whenever the discharging chamber becomes full. After the chamber has discharged itself, this outlet should be tightly closed. To make this arrangement automatic in its working, it is only necessary to substitute for the plug the Field Patent Siphon shown in Fig. 10.

A little judgment will be necessary in adjusting this apparatus to the lay of the land. If the absorption ground is to be placed at some distance from the house—and it should never be nearer than fifteen feet to any well from which drinking water is taken—it may be connected with the flush-tank by a vitrified pipe with very securely-cemented joints. These joints should first be packed with oakum, or with rags, to prevent cement from running to the inside of the pipe and making rough points to arrest foreign substances passing through to them, and they should be covered with a good band of the very best hydraulic cement—the joints not being covered with earth until it is quite certain that they are absolutely tight. This precaution is especially necessary in passing near a well. The absorption tiles should be two inches in diameter, and only one foot long, in order that the joints may be frequent.

DESCRIPTION OF FIELD'S FLUSH-TANK.—It is intended to be placed immediately outside of the walls of the house, and to receive all of its liquid wastes. It is made entirely of earthenware or of cast iron. The liquids pass through the grating of the pan (B), and are discharged through a trap which prevents the contained air of the tank from escaping. (C) is a socket for a ventilating pipe to

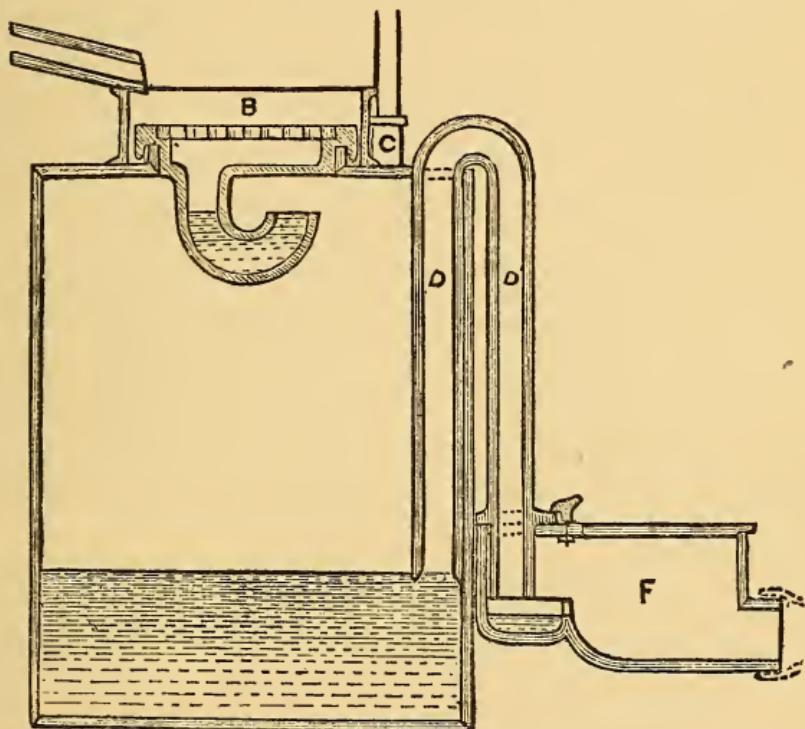


FIG. 10.—FIELD'S FLUSH-TANK.

carry this contained air to the top of the house. The tank holds about twenty or thirty gallons. This has no outlet save through the siphon (D). The outer end of the siphon enters a discharging trough, (F), which is made to turn to the right or left, so that its mouth may be directed as required

to connect the tank with the line of outlet pipes. This trough is of a peculiar shape which assists small quantities of liquid in bringing the siphon into action, instead of merely dribbling over the siphon without charging it, as they otherwise would do, and has a cover which can be removed to give access for cleaning.

When the tank is entirely filled, the pouring in of a few extra quarts of water, which is sure to occur at some time during the day, brings the siphon into action, and it flows copiously until the tank is emptied to the depth below which solid matters are permitted to accumulate, to be occasionally cleared out on removing the pan (B).

As the sink pipe discharges over the grating of the trapped inlet (B) outside the house, the connection between the drains and the house is completely broken, and any entry of foul air from the drain is rendered impossible. The top of the tank is perfectly closed by means of the water joint around the cover, and the cover is readily removed when required. The inlet, moreover, forms a basin, which may be used for throwing down slops outside the house.

When used for the *disposal of house slops where no regular system of sewerage exists*, the flush-tank enables all house refuse to be removed inoffensively—the bed-room slops being thrown down the basin at the top of the tank outside the house—and thus where earth or other dry closets are used for the excreta, this apparatus supplies a complete sanitary system of drainage. The concentration of the flow of the sewage effected by the sudden discharge of the tanks forces the liquid rapidly along the pipes, and prevents their being choked. The liquid can thus be distributed over a sufficient area

of ground to give full opportunity for the soil to purify it. The tanks are ordinarily made to contain twenty or thirty gallons in addition to space for deposit.

These directions should be carried out with some modifications, as described in the following pages.

For houses of a better class, where a larger outlay can be afforded and where the best results are desired, the details of the system as developed in extensive practice should be closely adhered to. The arrangement of the appliances provided for the work by Drainage Construction Company, which controls the patents relating to them, are set forth in the following chapter.

CHAPTER XXVI.

SUB-SURFACE IRRIGATION.

THE principle on which sewage is purified and its foul matters destroyed, in all forms of irrigation disposal, whether by broad surface irrigation, by intermittent downward infiltration, or by sub-surface irrigation, have been already explained. So far as the sub-surface system is concerned, it is essential to success that the sewage should be delivered intermittently and at considerable intervals; that it should be delivered near to the surface of the ground; and that the ground should be, naturally or artificially, so well drained that water will descend

through it readily; and that it should be of a sufficiently porous character for air to enter it freely.

The essential element of the system is a flush-tank which will retain all sewage issuing from the house during the intervals between two successive discharges into the drains. This ought not to be less than twenty-four hours; where the soil is not very free and porous, it should be extended, to as much as three days, according to the increasing closeness of the soil.

The tank should be automatic in its action, *i. e.*, it should not require watching or manual operation. There are a number of tanks which answer the purpose. The most simple and effective that has come to my notice is the one, described in the last chapter, invented by Rogers Field, Esq., C. E., of London, which has a self-acting siphon, brought into

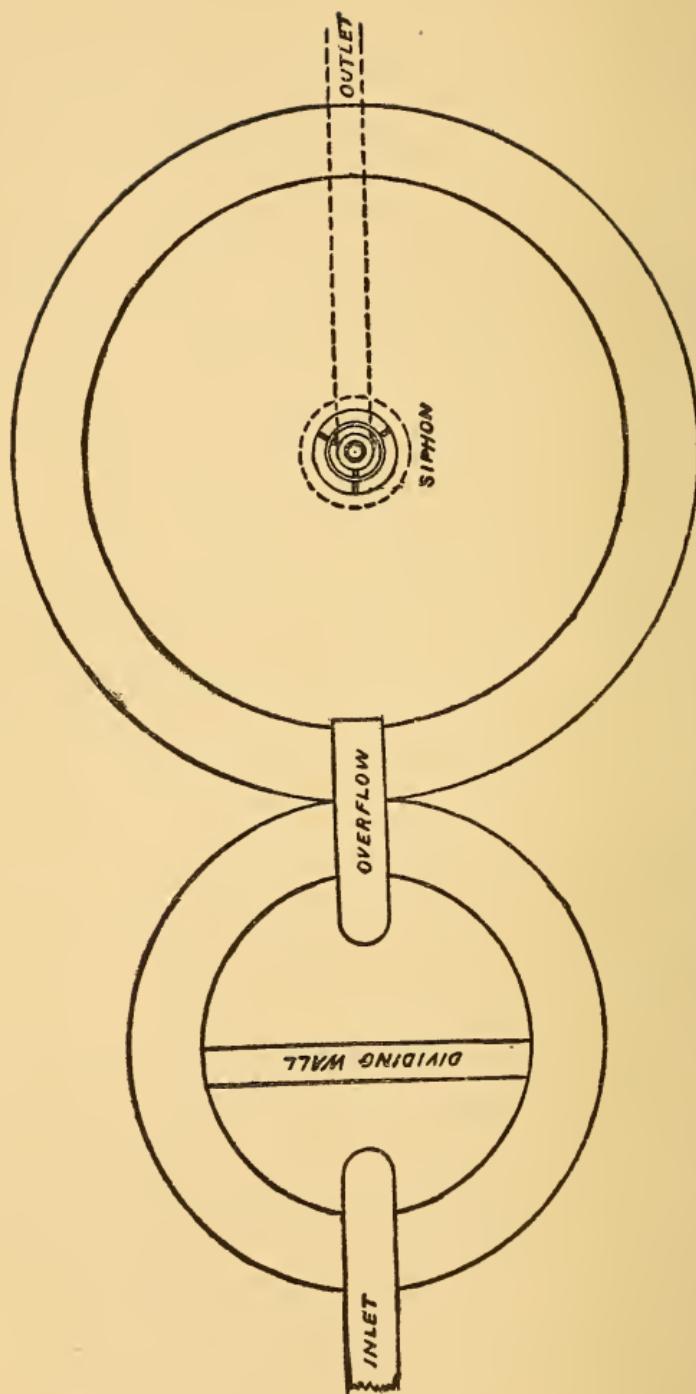


FIG. II.—SETTLING BASIN AND FLUSH-TANK—PLAN.

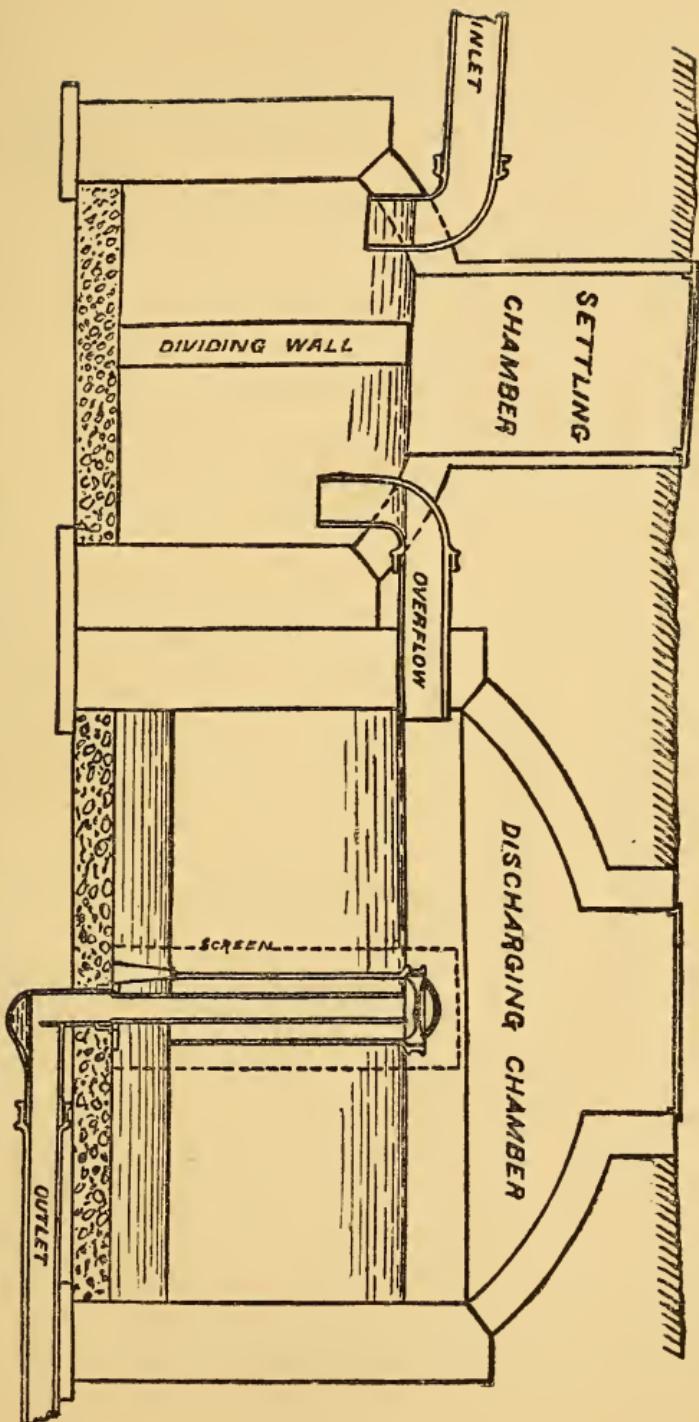


FIG. 12.—SETTLING BASIN AND FLUSH-TANK,—VERTICAL SECTION.

action and "broken" after the discharge by the simple movement of the liquid flowing into and out from it.

This tank, as modified in practice, is shown in figures 11 and 12. Its siphon is shown more in detail in figure 13. It consists essentially of the following elements. (1) A 2-inch iron pipe set with its hub downward at the bottom of the tank

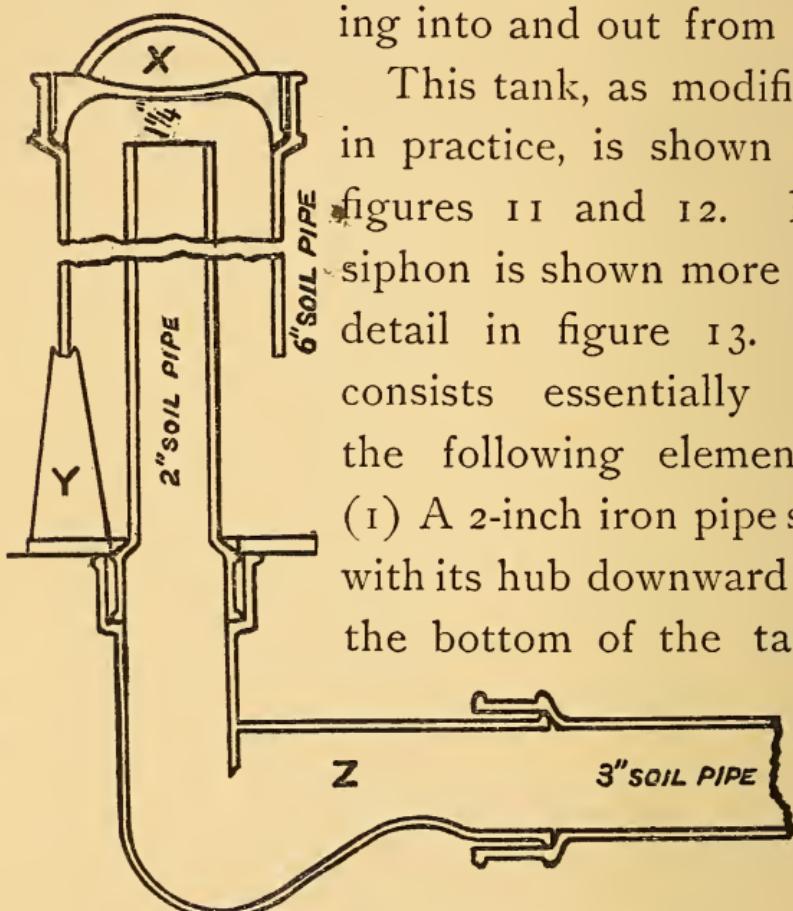


FIG. 13.—DETAILS OF ROGERS FIELD'S SIPHON.

and reaching to the height to which the tank is to be filled. (2) A 6-inch iron pipe set with its hub upward and closed at the top with a casting (X) carrying a handle

ledged into place after the usual manner of soil pipe jointing. The lower end of this 6-inch pipe rests on three (3) standards rising from a circular piece at the bottom of the tank. One of these standards is shown at Y. This constitutes the siphon proper, the annular space between the 6-inch pipe and the 2-inch pipe being the receiving limb, and the 2-inch pipe being the discharging limb. The water enters between the standards Y, rises to the top of the 2-inch pipe, flows over into it and is discharged through it. The lower end of this pipe delivers into a Rogers Field weir Z, a single casting of peculiar construction so arranged that with an abundant flow the outlet of the 2-inch pipe is sealed. The contained air is removed by the falling water, setting up a true siphonic action which continues until the liquid in the tank is reduced to the bottom of the 6-inch pipe—the intake

of the receiving limb. At this point air is taken into the receiving limb and the flow through the siphon is stopped. The contents of the 2-inch pipe continue to flow out through the weir-piece Z in which the water soon falls and admits air into the discharging limb. This causes the siphon to become completely emptied and no further flow can take place until the tank is again filled to the overflow point.

In constructing the flush-tank, the siphon is set in its center for convenient access to it through the manhole over it. The receiving limb is so arranged that it can readily be lifted for opening the discharging limb to inspection. In replacing it, care should be taken to rest it securely on the three standards Y.

Were the flow from the house pipe delivered directly into the flush-tank, it would carry with it paper and other sub-

stances which would soon obstruct the narrow water-way of the siphon and the small drain tiles in the irrigation field beyond. To obviate this difficulty, I introduced some years ago a settling chamber to receive the house drain with an overflow point below the constant water line, so that the discharge into the flushtank might be only from the comparatively clear liquid lying between the floating scum at the surface and the deposit of solid matter at the bottom.

It was found in time that even this was not sufficient, a strong flow from the house drain stirring up the deposited matters and causing them to be carried through the overflow pipe in sufficient quantity to interfere with the proper action of the drains.

As a further improvement I constructed in the settling chamber a vertical wall rising to the waterline and built level at

the top. This seems to accomplish all that is needed. The disturbance caused by the house drain is confined to the first division of the settling chamber from which the surplus flows over the top of the wall in a thin stream, which does not disturb the deposits on the side from which the flush-tank is fed.

The inlet from the house drain into the settling chamber is turned down below the water line, constituting a trap. The whole arrangement is sufficiently shown in figures 11 and 12, being a plan and section of the two chambers and their appurtenances.

The discharging chamber, or flush-tank, requires atmospheric pressure to drive its contents through the siphon. This is sufficiently supplied through the imperfect fit of the manhole cover, but as this may become obstructed with ice or dirt, the cover may be slightly perforated to insure a constant supply of air. Natur-

ally, the atmosphere of the flush-tank is foul ; but there is no circulation to bring it into active communication with the outer air. As the tank slowly fills, its air will be forced out imperceptibly. I have never known a case where the amount of windage necessary to work the tank led to any offense ; but as an extra precaution, it is better, if the tank stands very near to the house, to make a 2-inch hole in the side of the collar a little below the surface of the ground and to carry a line of drain tiles to a fence or bush or other convenient point, where it may be carried above the surface.

Were the discharging chamber to be absolutely tight, the only access for air pressure would be through the settling chamber, but this would cause its level to be carried down to the mouth of the overflow, carrying scum into the discharging chamber, where the result would be mischievous.

As an additional precaution, though hardly a necessary one, the collar of the settling chamber is made of 18-inch or 24-inch vitrified pipe, reaching down to the permanent water level. Its glazed surface prevents the absorption of moisture and impurities and the possible consequent bacterial growth upon it. Where the collar is built of brick it should be smoothly plastered with cement on the inside.

The outlet from the tank is made by connecting a single length of 3-inch iron soil-pipe with the end of the weir piece Z. This carries it out beyond the wall of the tank, where it is connected with 4-inch vitrified pipe, with cemented joints, leading to the irrigation field, more or less distant.

For protection against frost, it is better that this pipe should be nearly or quite two feet below the surface of the ground at

every point. It should have a regular fall from the tank to the connection of the drains, but the fall should be slight. Four inches per 100 feet (1 to 300) is ample and is better than a steeper inclination.

There are many cases of course where the ground between the flush-tank and the irrigation field can not be reached on a reasonably direct line without much greater fall. In such cases the steeper fall should cease at least 20 feet above the beginning of the drain tiles, and the remaining distance should be carried on a very slight grade so that the velocity may be checked and the delivery into the tiles made more gradual.

It is immaterial whether the drain tiles branch out from the side of the main connecting pipe or from a cross drain into which this enters.

It is very desirable that the whole

system should be entirely emptied at the end of each discharge. Therefore the 2-inch branches of the vitrified pipe which are to connect with the 2-inch tiles should

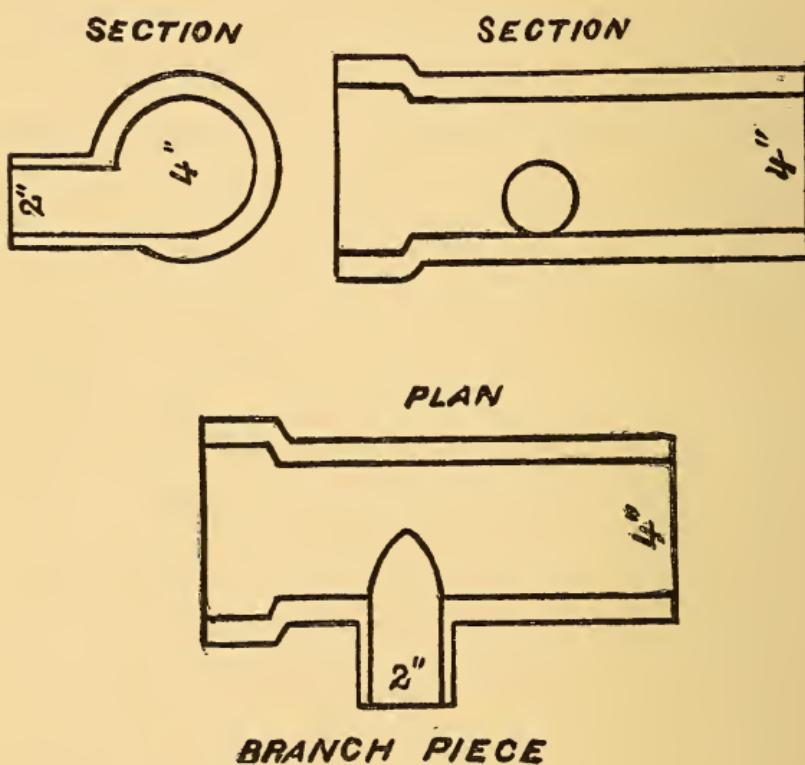


FIG. 14.

come out, not from the middle of the main pipe, as in sewer work, but from the extreme bottom, as shown in figure 14. Irregularities of the ground will some-

times make it necessary to bring these branch pieces very near to the surface. In other cases it is necessary to start the drain tiles out at a considerable depth.

The rule should be followed that all joints should be uncemented which are less than 18 inches from the surface, and all should be cemented which are more than that distance from the surface, no matter whether they be joints of the vitrified or of the tile drains.

The arrangement of the tiles in the irrigation field will depend entirely on the formation of the surface of the ground. They should have a very slight fall, as a rule not more than 2 inches per 100 feet. In level ground they may be laid straight and exactly parallel to each other, while in irregular ground they must follow quite closely the contour of the surface. Occasionally artificial grading is required to prepare the field to receive them, but

ordinarily by a sufficient deviation of direction the lines can be made to accommodate themselves to the necessary slope.

They should lie on a bed, never more than 12 inches and preferably not less than 10 inches below the surface and their fall ought not to exceed 2 inches to 100 feet (1 to 600).

Theoretically, all that is required is to lay 2-inch draining tiles, slightly open at the joints, on a true grade and cover them in the usual manner. Under the best arrangement, however, it is at times necessary to lift some of the tiles to remove obstructions, and as the grading must be very carefully done and carefully preserved, it is best to lay in the bottom of the trench permanent earthenware slabs or gutters, to preserve the grade. Furthermore, for perfect freedom of discharge, it is well to lay the tiles with open joints of about one quarter of an

inch between them. Such a joint, if unprotected, would soon be filled by earth working in from above, as when the field is walked upon. To prevent this, a narrow cap is laid over each joint.

The construction and combination of these parts of the irrigation drain are shown in the illustrations.

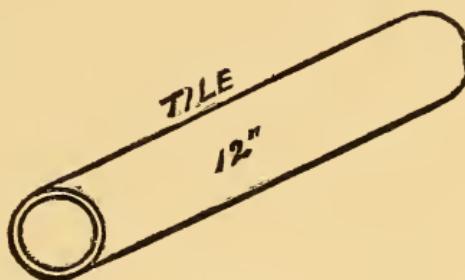


FIG. 15.

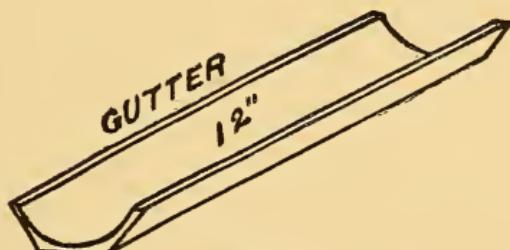


FIG. 16.

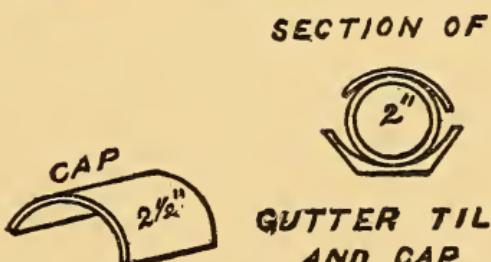


FIG. 17.

GUTTER TILE
AND CAP

FIG. 18.

Figure 15 is the tile, round, two inches in diameter and twelve inches long. Figure 16 is the gutter of the same length, quite

shallow, and made of a larger radius than the outer circumference of the tile, so that it will close the joint only along the immediate line at the bottom. Figure 17 is the cap, two and one-half inches long, also of larger radius than the tile. Figure 18 is a cross-section showing the combination of these three elements, and figure 19 shows the manner in which they are laid in the ground.

To illustrate more fully the manner in which the whole system is applied we will assume the case of a household of ten persons, producing five hundred gallons of liquid wastes per day, living in a house from which the ground slopes slightly toward an area, preferably of grass land, about $60 \times 75^*$ feet square, and

* If the available ground is of restricted area the drains may safely be placed at intervals of three feet, using one branch piece and one plain piece alternately for the cross-drain.

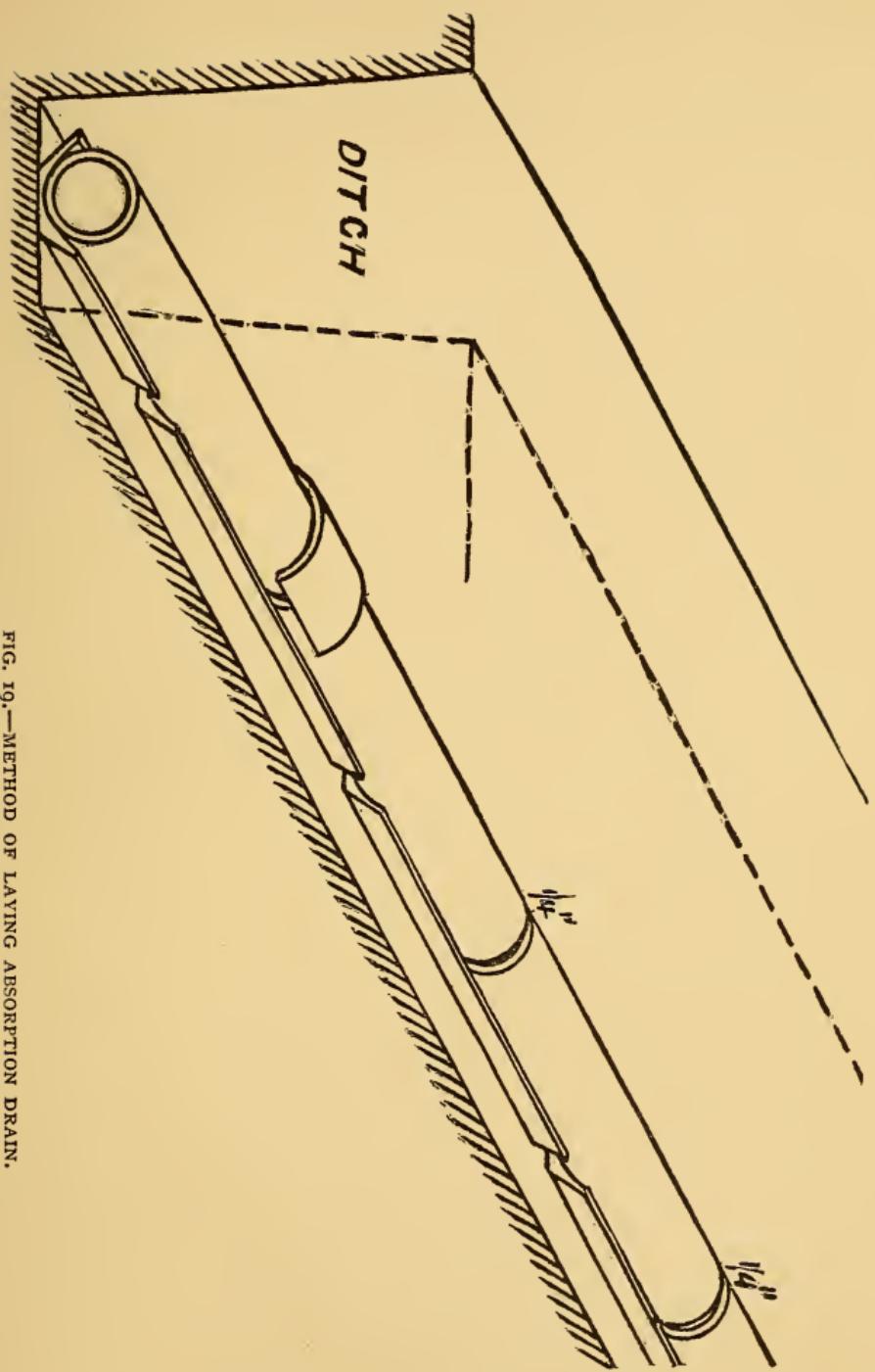


FIG. 19.—METHOD OF LAYING ABSORPTION DRAIN.

the soil of which is of a light and porous character.

Let the settling-chamber and flush-tank be built fifty feet from the house, preferably among shrubbery. The four-inch house drain delivers into the first compartment of the settling chamber, in the manner shown in the cut, and the sewage flows from this into the second compartment and thence into the flush-tank. The settling-chamber should hold about two hundred and fifty gallons and the flush-tank should have a capacity of about five hundred gallons between the bottom of the receiving limb and the top of the discharging limb of the siphon. The cover of the discharging chamber may be perforated with four half-inch holes.

From the outlet of the siphon, a four-inch pipe, laid with cemented joints and about two feet or more below the surface of the ground, leads to the edge of the

irrigation field with an inclination of four inches per hundred feet. At this point it enters by an ordinary 4x4 **T** branch into the side of a four-inch pipe running at right angles to it. This pipe is made of sections of plain pipe two feet long with branch pieces to connect with the tiles, one foot long, so that by placing one branch piece between each two plain pieces tile connections are furnished at intervals of five feet. The drainage field being sixty feet long we shall require, to give the one thousand feet of drain necessary under the assumed conditions, sixteen branches occupying a width of seventy-five feet.

We will assume that the irrigation field is brought to a uniform slope in the direction in which the tiles are laid of two inches per hundred feet, and that it has an abrupt elevation of one or two feet at its upper end to give sufficient covering to the cross-drain.

Sixteen parallel trenches, sixty feet long, should be dug from each branch-piece of the cross-drain to the opposite side of the field. It will be worth while to bring these, by careful leveling, to a very exact grade. Their depth should be a little more than ten inches. In the bottom of these, gutter-pieces should be laid and firmly bedded in continuous lines. On these gutter pieces let the tiles be laid, beginning at the upper end. The joints should be spaced by using a thick piece of sole leather as a gauge. The cap-pieces should be laid over the joints and the whole should then be carefully covered and filled in at the sides with earth free from lumps or stones. After the caps are securely covered the rest of the filling may be shoveled in and well trodden down and the sods replaced.

If constructed with care and in strict compliance with these directions, the

whole system may be relied on permanently—perhaps perpetually—as an efficient means for the disposal of whatever liquid wastes the household may produce.

Like all other human appliances, however, the work will require some intelligent supervision and care. It may or may not be necessary from time to time to remove the scum and sediment from the settling chamber. Ordinarily the flow through a 300-gallon chamber will remove the solid matters, as they decompose and become macerated, about as fast as they are delivered. Sometimes this is not the case, but the necessity for hand-cleansing is very rare. A thick scum forms almost immediately, but it rarely becomes so thick as to interfere with the proper flow of the liquid.

The flush-tank should be looked to from time to time to see that it is discharging properly; but it rarely needs

further care than the occasional lifting of the six-inch pipe and an inspection of the discharging limb.

With regard to the irrigation field, it needs no attention whatever, so long as the tiles remain open. When they become obstructed the fact is made manifest by the cessation of the rank growth over the active tiles, indicating a stoppage which prevents the sewage from flowing on through the remainder of the drains. Sometimes, where the amount of drain is insufficient, the sewage will rise to the surface if an obstruction prevents its flowing through the whole length of the drains. In either case, it is only necessary to dig down carefully to the level of the gutter, remove a few of the pipes, clean them out and replace them. The removal, cleansing and replacing of one hundred feet of drain ought easily to be done in half a day, and the removal of such amounts,

where the work has been well executed at the outset, is rarely required.

For smaller households, the amount of sewage to be treated is less, of course, and a much smaller irrigation area will suffice, and a smaller tank.

A piece of ground fifty feet square, having ten rows of tiles five feet apart and fifty feet long, will suffice for even a large household with an abundant water-supply. For the better illustration of the arrangement of this system, I give in figure 20 a plan for the work in the case of lot fifty feet wide, with a depth of open ground behind the house of somewhat more than fifty feet. The leaching drains may safely begin at a distance of even ten feet from the back of the house, requiring for the whole a clear area of only fifty feet by sixty feet. With still smaller households the length of drain may be very much shortened. In my own case,

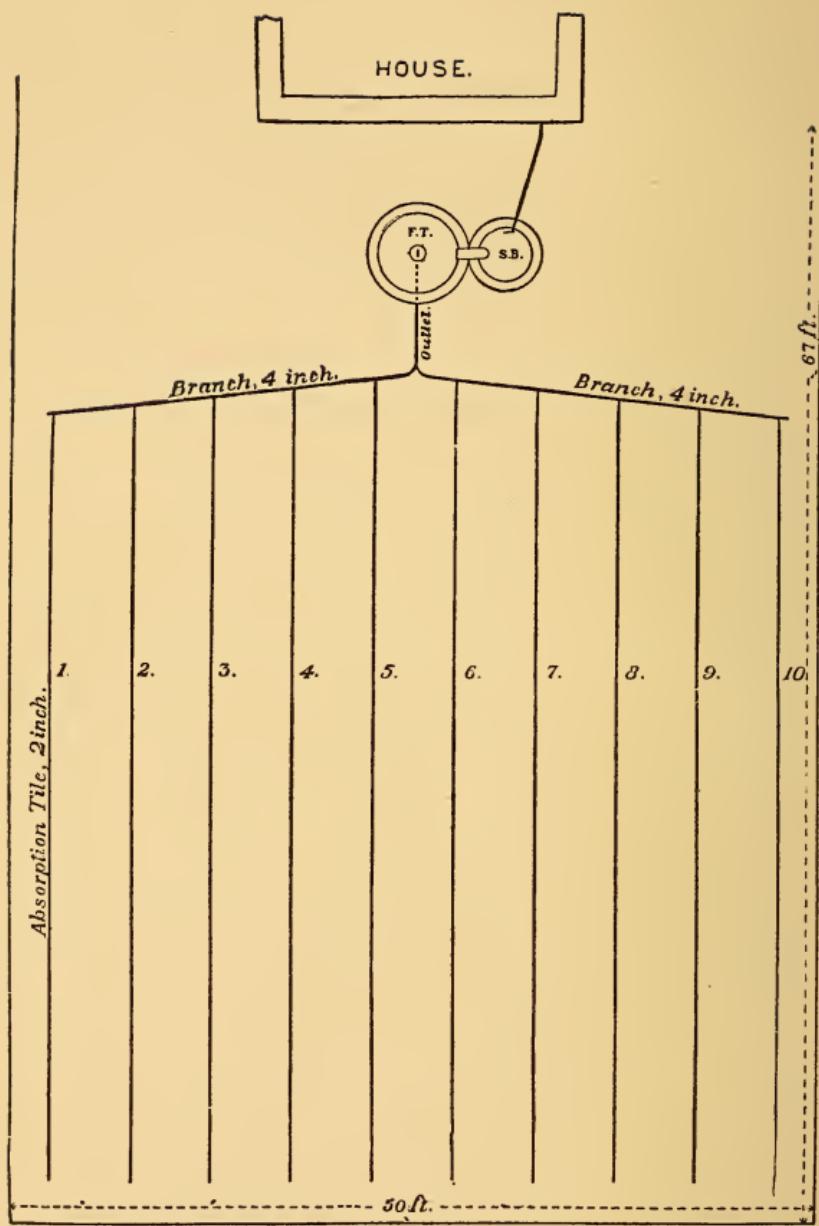


FIG. 20.—ARRANGEMENT OF FLUSH-TANK AND DRAINS FOR A SMALL LOT.

where water-closets were not used, the total length of irrigation drain was only two hundred feet.

The length of tile required for a given number of persons, or for a given amount of sewage, depends on the porosity of the soil, and thus far there has been no sufficient experience to determine what the variation should be for soils of different porosity. Heavy clays are never so well suited to the work as lighter loams, but they can be made measurably good by very thorough and deep drainage. The working of the system in the case of such clays can be very much improved by filling the trenches, after the laying of the tile, with sand, gravel, or fine cinders.

I have had all manner of soils to contend with in the construction of these works, and I have never yet found a single case where, with a sufficient extension of the system—within reasonable

limits—a good result could not be attained. The irrigation field connected with the Woman's Prison, referred to above, would be very satisfactory if the amount of sewage delivered to it were in proportion to the amount delivered by an ordinary household.

There is one objection to this system as described, which must not be ignored. The settling basin is a cesspool. It retains organic waste matter in a state of noisome decomposition. It is, however, made perfectly tight, so that there is no possibility of the escape of its foul contents by leakage. Its water-level is never changed, so that no pressure is brought to bear upon its limited atmosphere, and it is traversed by a stream of water amounting to fully twice its capacity every twenty-four hours. This stream removes its putrefying contents as they are produced. The most

that can be said in its disfavor is that it is worse than any necessary accompaniment of disposal by a system of sewerage ; but, except by regular sewerage, there has yet been found no efficient way to obviate its use. It certainly reduces the cesspool nuisance to the smallest possible limits, and I think we may safely trust it, confined and guarded as it is, to produce no exhalations which can do harm through its tight cover or through the well-ventilated drains leading from it to the house. The fresh-air inlet for the drainage system of the house should be placed near to the flush-tank, so that the whole system may be thoroughly supplied with air.

In the foregoing remarks, it has by no means been attempted to give full directions for the guidance of house-drainage

work, but rather to set forth certain points for the information of house-builders. The plumber is, and, with the general public, will long remain, the final authority in the decision of all questions arising. The better plumbers—those who keep themselves intelligently informed as to improvements in their art—will be a very useful authority; all plumbers, when brought face to face with the average householder, are a masterful authority, and their control is generally complete. The information here given may, now and then, either aid them to better judgment, or enable their clients to modify their practices in some important respects.

THE END.

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